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THE ANATOMY OF THE GYROSCOPE

**(A Report in Three Parts Comprising a Literature and Patent Survey Directed to the
Gyroscope and its Applications)**

by

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Published February 1988

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ISBN 92-835-0441-0



Printed by Specialised Printing Services Limited
40 Chigwell Lane, Loughton, Essex IG10 3TZ

FOREWORD

A literature survey on The Gyroscope and its Applications was compiled by Dr-Ing. Helmut Sorg and published in December 1970 (AGARD-Report-582). In a foreword to the report Professor C.T.Leondes stated that its purposes were to offer engineers and scientists a listing of books which were readily available, to broaden the knowledge and to prevent a duplication of research in the field of gyroscopes. That most useful report is a comprehensive list of all the books which may be readily consulted, but it includes nothing from the patent literature nor anything from the vast store of technical papers on the subject that are to be found in the learned journals of the world.

A complete survey of the whole subject is too large for any one man to tackle successfully.

In this new report, Mr Frank W.Cousins has worked for fourteen years in the great libraries of London and has produced a most scholarly work which makes great inroads into material, the whole of which would take several lifetimes to exhaust.

He thus carries on the work that Dr Sorg initiated with AGARD and reiterates the belief of Professor Leondes, that it will contribute to the broadening of human knowledge in this difficult, but fascinating subject. The report is in bibliographical form which implies that it is a symbol of a constantly-growing organism in a way more closely allied with the subject than any text can hope to be.

Eric R.Laithwaite
Emeritus Professor of Heavy Electrical Engineering
Imperial College, London

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ACKNOWLEDGEMENTS

I wish to acknowledge my special debt to Mrs V. Tattle of The British Library who has given me generously of her skill over many years of research; the Trustees of the British Museum; The Controller of H.M. Stationery Office, The Comptroller General of Patents and The Commissioner of Patents and Trade Marks of the United States Department of Commerce.

I am further indebted to my friends Professor Eric Laithwaite, Mr Derek Lever and Mr Ralph Arnot for help and encouragement over more than a decade.

Many have given permission generously for me to reproduce photographs and other material. I wish especially to acknowledge the kindness of Dr Glyn Daniel of *Antiquity*; Joy Maggs of Sperry Ltd; The Director & Secretary of the Science Museum, London, The Teylers' Museum; Spaarne Haarlem, The Neils Bohr Library, Museum of the History of Science Oxford University, The Bodleian Library the Kunsthistorisches Museum, Vienna, the Plenum Publishing Corporation of New York, my friend Basil Minett now retired of British Aerospace and my friend M. Alain Brieux the distinguished historian of science for allowing me to show *inter alia* the gyroscopic transmission of our mutual acquaintance the late M. Bernard Salomon.

Finally I wish to thank Mr J.L. Hollington, Dr G. Beardmore and Mr D.S. Markham of Smi'as Industries Aerospace & Defence Systems Ltd, also Lt Colonel P. Carré FAF; Lt Colonel A. Rocher and Professor Dr Ing. R.C. Onken of AGARD for their interest in and active support of my work.

Frank W. Cousins
Westminster 1987

PREFACE

The purpose of this report is to direct the student of the gyroscope and gyroscopic phenomena to that *terra incognita** of technical literature that resides primarily in the patent literature of Great Britain and the United States of America**, augmented by that which resides in the technical journals of each of those nations and those of the U.S.S.R. I have tried to review all of the British patent specifications, but I am well aware that there may be some lacunae.

I have not been able to extend my researches into a complete examination of the patent specifications of the United States of America, but where I do record them, and provided they have a number higher than No. 2415067 of c.1947, then each U.S. specification will itself provide a review of the related prior art. Hence each U.S. specification is itself a valuable reference to a much deeper field of enquiry. It is the same with the learned journals of the World, each paper will carry a useful bibliography and again the field of enquiry is remarkably extended thereby.

I have seen all of the entries I have made and I have given the names of the Journals in full to try to save the confusion that surrounds the present poor state of bibliography.

To produce this report has taken fourteen years of research, and I think I may be allowed to draw attention to that part that deals *inter alia* with gyroscopic gears. The subject has not previously appeared in any text on gear design, and is to be found, as far as I am aware, solely in the patent literature. I offer it here, for the first time to a wider audience.

Frank W. Cousins
Westminster. 1987.

* The term is not too extravagant since The British Library in London holds in excess of twenty two million patent specifications.

**The research has been primarily in British and American patent specifications and in consequence corresponding foreign patents may exist. The reader is directed to study the problem from Derwent Patent No. Family Index which began in c.1974.

L'objet du présent rapport est d'orienter l'étudiant du gyroscope et des phénomènes gyroscopiques vers cette *"terra incognita"** de la littérature technique. Celle-ci se trouve principalement dans la documentation concernant les brevets en Grande Bretagne et aux Etats Unis** et dans les revues et journaux techniques de chacune de ces nations ainsi que de l'URSS. Je me suis imposé comme tâche de passer en revue toutes les spécifications de brevets britanniques, mais je suis conscient du fait qu'il pourrait y avoir des lacunes.

Je n'ai pas été en mesure d'élargir le domaine de mes recherches afin de présenter une revue exhaustive des spécifications de brevets des Etats-Unis, mais là où j'y fait référence — et pourvu qu'il lui soit attribuée un numero supérieur au No.2415067 du c.1947 — chaque spécification US fournira d'elle-même un aperçu de l'état de l'art pré-existant. Chaque spécification US sert donc de référence précieuse à une activité de recherche plus approfondie. Il en est de même pour la littérature savante du reste du monde, où chaque communication comporte des références bibliographiques de valeur, qui serviront aussi à élargir le champ des recherches de façon considérable.

J'ai examiné personnellement tous les documents inclus dans mon rapport et j'ai cité les noms des différentes revues en toutes lettres, en espérant ainsi éviter la confusion qui caractérise la situation actuelle médiocre de la bibliographie dans ce domaine.

Le présent rapport représente un travail de recherche de quatorze ans, et je pense qu'il me serait permis de signaler la partie qui traite *inter alia* des engrenages gyroscopiques.

Ce sujet ne paraît nulle part ailleurs dans les textes concernant la conception des engrenages, et à ma connaissance, il n'est traité que dans la littérature des brevets. Je le propose, pour la première fois, à un public plus large.

Frank W. Cousins
Westminster 1987

* Le terme n'est pas trop fort puisque la British Library de Londres contient plus de 22.000.000 spécifications de brevets.

**Nos recherches ont porté principalement sur les spécifications de brevets britanniques et américains, et par conséquent, il se peut qu'il existe des spécifications étrangères équivalentes. Nous attirons l'attention du lecteur sur le Derwent Patent No. Family Index, qui date de c.1974.

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PART III

HISTORICAL NOTES AND COMMENT ON MATERIAL IN PARTS I & II*

*Published as a separate volume

PART I

1. SOME IMPORTANT WORKS DIRECTED TO THE GYROSCOPE.

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3.3.1 Authors

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 Johnson V.E. iii (1911)
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 Morris J. (1950)
 Motorina N.N. (1985)
 Perry J. (1890) (1919)
 Resal A.H. (1893)
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 Stamkart F.J. (1854)

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4.3.2 G.B. Patent Specifications

No Entries

4.3.3 U.S. Patent Specifications

3783550
4200283

4.4 Serson's Gyroscopic Sextant and Improvements

4.4.1 Authors

Anon (1905)
Baule A. (1890)
B.J. (1754)
Favé L. (1904)
Fleuriais G.E. (c 1886-1900)
Gruey L.J. iv 1888
Heinrich G. von i ii (c1951)
de Jonquieres i ii (1886)
Roosenburg L. (1909)
Short J. (1751)
Swinburne J. i ii (1915)

4.4.1 Authors

Anon (1905)
Baule A. (1890)
B.J. (1754)
Favé L. (1904)
Fleuriais G.E. (c 1886-1900)
Gruey L.J. iv 1888
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Roosenburg L. (1909)
Short J. (1751)
Swinburne J. i ii (1915)

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1192532	1857736	2871705
1310862	1984859	

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4.5.1 Authors

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 Kane T.R. Levinson D.A.
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 Koenigs M. (1891)
 Markeev A.P. (1984)*
 Resal A.H. (1893)
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 Smith A. (1839)
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 Stefanini L. (1979)
 Stewartson K. Ward G.N. (1959)
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 Vakhaniia N.N. (1965)

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4.6.1 Authors

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 Epstein P.S. (1919)
 Kronig R. and Rabi I.I. (1927)
 Kruger F. von (1916)
 Laporte O. (1933)
 Planck M. (1916)
 Reiche F. and Rademacher H. (1926-1927)
 Verbrugghe F. (1953)
 Wang S.C. (1929)

4.7 Very High Speed Rotors

4.7.1 Authors

Beams J.W. (1930) (1933), (1947)
 Colwell R.C. Hall N.I. (1935) (1936)
 Girard P. Chukri Ch. (1933)
 Herriot E.J.C. & Huguenard E.A. (1927) (1925)
 Pickels E.G. Beams J.W. (1935)

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250207

4.8 Tippe Top

4.8.1 Authors

Braams C.M. i ii (1952)
 Colwell R.C. Fullmer L. (1938)
 Delcampo A.R. (1955)
 Dresden D. (1951)
 Fokker A.D. (1952)
 Haringx J.A. (1952)
 Hart J.R. (1959)
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 Isaeva L.S. (1959)
 Jacobs J.A. (1952)
 O'Brien S.J. Synge J.L. (1954)
 Parkyn D.G. (1956)
 Pliskin W.A. (1954)
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 Schuh F. (1953)
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653172
656540

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1644182
2332507
2700246

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811096
889574

4.9 Toys, Tops

4.9.1 Authors

No Entries

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806-1858	6359-1887	16572	14329
2820-1861	12058	24143	17349
676-1862	16705	5082-1895	18222
754	7338-1888	11199	3697-1904
2643	11126	12181	17640
1129-1863	11733	12267	25293
119-1866	11955	12286	6858
2765	14190	15609	28000
3308-1868	15194	15796	28602
322-1869	15717		16974-1905
150-1870	16787	19328	5860-1906
1933	17211	19675	9496
3155	18967	20651	16228
3077-1872	3025-1889	24001	21921
1229-1873	7018	1044-1896	25696
2832	14202	12265	4114-1907
204-1878	576-1890	12917	11915
3533	4385	19342	20102
2799-1879	4814	22904	20413
5031-1880	9629	1070-1897	25783
50-1881	14713	10426	10174-1908
200	6290-1891	25401	19146
4934	8686	9410-1898	25732
4748-1882	12090	10332	5109-1909
946-1883	13480	11923	7591
1287	13806	15814	8197
3324-1884	15717	16092	13225
5135	2827-1892	22759	29144
5597	4453	2655-1899	11705-1910
12671	4920	14264	13321
16432	6687	14770	17210
2752-1885	6818	24211	18998
9890	8139	24639	24409
10471	10491	25327	10572-1911
10944	13868	3028-1900	18749
12597	18997	5998	20686
13049	6329-1893	18966	29092
14669	9283	7899-1901	3292-1912
3207-1886	16246	8020	3511
7717	19222	18490	18891
9978	21457	20170	22886
10941	8142-1894	6632-1902	23640
12695	8488	11261	5172-1913
	9096	17654	19583

6404-1914	286625	545662	1008765
2746-1915	290596	586825	1015000
15289-1915	292899	588016	1047915
103381	295542	588285	1054476
106238	301791	590795	1082529
124653	316510	599359	1111799
132470	356875	610235	1123177
136741	371455	611947	1143706
140142	390512	634937	1150817
150621	401170	644103	1181333
155638	404772	653172	1228917
156856	411923	656540	1235153
160944	413525	656951	1240017
173096	416208	666803	1250360
179813	420086	670873	1255715
189941	420931	698082	1256545
190896	429563	702554	1262394
192019	442452	780571	1281045
194714	444352	806488	1310243
201657	447750	861674	1402126
223834	457390	870242	1432854
266208	472000	877184	1570304
284936	472387	943314	
286577	545511	974588	

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76572	999247	1546451	2762162
78745	1011202	1567405	2794644
182696	1022236	1571901	2879066
346921	1098895	1575264	2945696
459832	1161552	1579341	3036836
465578	1188488	1587127	3137966
481830	1321589	1595611	3143347
514995	1351630	1610530	3287846
607552	1363718	1629326	3330067
645858	1374243	1687239	3370377
667794	1395261	1699984	3858348
680957	1435580	1780547	3863925
698286	1451818	2023297	3879887
755446	1452618	2039819	3906660
814962	1469151	2145608	3933356
884975	1475975	2311453	3936974
897137	1501276	2332507	3939601
918545	1529263	2493834	3945146
919349	1535502	2573916	3959917
925479	1545860	2583805	
929669		2639921	

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112267	297867	448328	511362
117459	329819	452611	515587
130596	335286	452727	520594
144350	340701	453968	520595
175398	358677	459802	541532
176129	360879	459803	561477
180277	361938	463404	561942
205487	366075	466026	561970
217669	372556	466068	568743
219748	372701	468160	573009
229662	395136	469000	575524
232113	398148	469266	582363
323609	400607	472274	589369
234248	433944	470380	610354
234366	434907	475730	610443
257709	436105	485414	612144
268813	441693	495927	613285
280768	443788	499501	

Musical Tops

101681	596183	913276	1074460
283126	1040434	932174	1084182
238236	1040435	941774	1094171
304516	1144635	1014006	1104411
309568	657112	1005881	1113403
345547	811096	1009079	1152048
382364	889574	1035549	1180291
591566	911715	1040952	1265634

Colour Tops

191183	358180
203784	390262
213915	416057
282340	485415
343911	594779

Water Top

461033

Pistol Firing a Top

300505
433943
437765
448180
551660
589170

Plural Tops

117072	1217250	1912512	2018444
227768	1265634	1931733	2020596
339390	DT1478328	1948509	2024435
382584	1603214	1949852	2105688
391528	1703160	1957003	2129483
400876	1728035	1962020	DT2361232
435645	1816474	2011999	DF2532082
1213323			

5. THE DISCOVERY OF THE GYROSCOPE AND RELATED PHENOMENA

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5.2 Bohnenberger J.G.F. i ii (1765-1831)

5.2.1 Authors

Dailey H.B. (1901) *
 Person C.C. (1852)

*This contains a reference to Bohnenberger apparatus driven by static electricity

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5.3 Lamarle A.H.E. (1806-1875)

5.3.1 Authors

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5.4 Johnson W.R. (1831) (Rotoscope)

5.5 Foucault J.B.L. (1819-1868)

5.5.1 Authors

Barnard J.C. iii (1874)
 Bertrand J.L.F. (1856)
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 Villarceaux Y. (1855)

6. THE EARLY GYROSCOPE

6.1 General

- | | | | |
|------|------------------------|--------------------------------|--------------|
| 6.2 | Plücker's contribution | Plücker J. | 1801-1868 |
| 6.3 | Jacobi's contribution | Jacobi M.H. | 1804-1874 |
| 6.4 | Magnus' contribution | Magnus H.G. | 1802-1870 |
| 6.5 | Fessel's contribution | Fessel F. | 1821-c. 1860 |
| 6.6 | Kelvin's contribution | Kelvin Baron (William Thomson) | 1824-1907 |
| 6.7 | Gilbert's contribution | Gilbert L.P. | 1832-1892 |
| 6.8 | Sire's contribution | Sire G.E. | 1826-c. 1891 |
| 6.9 | Gruey's contribution | Gruey L.J. | 1837-c. 1888 |
| 6.10 | Trouvé's contribution | Trouvé G. | (c.1890) |
| 6.11 | Hopkins' contribution | Hopkins G.M. | (c.1890) |
| 6.12 | Sperry's contribution | Sperry E.A. | 1860-1930 |

6.13 Sonya Kovalevsky's contribution —
c.1875

6.14 Early Patents (Before 1900)

6.2 Plücker J.

6.2.1 Authors

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6.3 Jacobi M.H.

6.3.1 Authors

Pavlov V.A. iii See Finn B.S. re Jacobi Dictionary of Scientific Biography Scribner (1973) 7 p55
Taylor W.C. (1841)

6.4 Magnus H.G.

6.4.1 Authors

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6.5 Fessel F (1821-?)

6.5.1 Authors

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Wheatstone C. (1854)

6.6 Lord Kelvin (Thomson W.)

6.6.1 Authors

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6.7 Gilbert L.P.

6.7.1 Authors

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6.8 Sire G.E.

6.8.1 Authors

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 Sire G.E. i ii iii iv v (1826-1891)

6.9 Gruy L.J.

6.9.1 Authors

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6.10 Trouvé G.

6.10.1 Authors

Barral G. (1891)
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 Trouvé G. i ii (1890)

6.11 Hopkins G.M.

6.11.1 Authors

Durant E (1905)
 Hopkins G.M. (1890)
 Peckham W.C. (1905)

6.12 Sperry E.A.

6.12.1 Authors

Sperry E.A. i ii iii iv v vi vii viii ix x xi xii 1910-1913
 Hughes T.P. (1971)
 Huntsaker J.C. (1955)

6.13 Kovalevsky S. (1875)*

6.13.1 Authors

See Kramer E.E. (1973)
 Tabor M (1984)
 Polubarynova-Kochina P. (1957)

*Alternative spelling Kovalevskaya

6.14 Early Patents (Before 1900)

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1855	917 Smyth C.P. 1437 Bellford A.E.L.	1880	5031 Biggs J.C.
1856	1184 Smythies J.K.	1881	50 Wrigley T. 200 Imray J. 4934 Wier M.A.
1857	2159 Bosworth J.A. 2676 Garvey B.	1883	946 Lake W.R. 1287 King A.A.
1858	806 Gorham J.	1884	5135 Hall W.H. 6842 Falkner V. 8394 Pitt S. 8597 Martin G. 13671 Britain W. 15459 Dobson A.J. 16432 Bishop R.H. 16432 Parr E.
1861	2820 Brooman R.A.	1885	2752 Whiteley J. 9890 Newson J. 10471 Whittuck W.S. 10944 Parr E. 12597 Leech A.A. 13049 Cole G. 14669 Duncan W.H.
1862	676 Tothausen F. 754 Beaumont A.A. 754 Escalier J.A. 2643 Hirsch H.	1886	3207 Heinrich E. 7717 Sambrook J.H. 9978 Stead J. 10941 Fischer G. 12695 Pascall J. 13162 Packard E. 14208 Tower B. 15004 Browett A.
1863	1129 Gedge W.E. 3231 Winans W.L. 3231 Winans T.	1887	6359 Lutticke G.F. 12058 Cole G. 16705 Valda A.H.
1866	119 Brooman R.A. 2765 Abel C.D.	1888	1162 Griffin E.C. 7338 Jewell F. 11126 Butlin W.C. 11733 Briggs O.P. 11955 Fischer G. 14190 Jewell F. 14190 Cole G. 15194 Hill W. & J. 15717 Cole G. 15717 Jewell F. 16787 Bennett J.F. 17211 Dickinson H.Y. 18907 Duff J.
1868	3308 Blanchon F.A.		
1869	322 Bate H. 3707 Bessemer H.		
1870	150 Bussey G.G. 553 Bessemer H. 1559 Bessemer H. 1580 Bessemer H. 1742 Bessemer H. 1933 Bussey G.G. 3155 Clews J. & F.		
1872	3077 Fenby J.B.		
1873	1076 Bessemer H. 1229 Péan L.M.R. 2832 Péan L.M.R.		
1874	3274 Bessemer H. 3552 Gray J.M.		
1878	3533 Wier M.A.		

1889

1122 Hunt E.
3025 Jones A.S.
4117 Packard E.
7018 Cole G.
14202 Fischer G.
20220 Tower B.

1890

1031 Peichl J van
576 Gill C.E.
4385 Oakley F.
4814 Auras G.
4814 Wilke P.
7407 Huntington F.A.
9629 Pilkington R.
9809 Lake H.H.
14713 Horn W.W.
19886 Maxim H.S.

1891

6290 Saunders T.
8686 Cairns S.
9437 Peichl J van
12090 Brown J.L.
13480 Crosby G.G.
13480 Knight H.
13806 Quine R.H.
18717 Andrews J.
20228 Noble P.C.

1892

2827 Lehmann E.P.
4453 Gozzard A.
4920 Dencède A.V.
6687 Pilkington R.
6818 Gray J.
8139 Imray O.
10491 Hall E.
13868 Hall E.
18997 Parsons J.F.

1893

6329 Green A.G.
9283 Adam C.
8500 Atkinson E.H.
16246 Heinrich E.
16246 Houfer H.
19222 Humphries A.
18133 Justice P.M.**
21457 Shackelford J.H.
21457 Brown H.E.

1894

8142 Cave J.A.
8488 Clarke J.
9096 Coffin H.R.T.
11214 Thomson W.P.
16572 Barnes S.

22296 Obry L.
19824 Bradley P.B.
24143 Erhard S.

1895

5082 Lane J.
11199 Murgatroyd W.J.
12181 Howard J.B.
12267 Barus C.
12286 Waters R.B.
15609 Bishop H.R.
15796 Wier M.A.
19328 Boyum J.
19675 Brockman L.
20651 Cyngell C.E.
24001 Avery W.
24001 Venables J.

1896

1044 Weir M.A.
12265 Hawkings W.H.
12917 Gregory E.
19342 Thompson W.P.
22904 Rayner E.S.

1897

1070 Lehmann E.P.
10426 Herbert A.G.
10426 Baker F.R.
12169 Jones A.E.
18036 Lusty F.
25401 Haddan R.
23683 Kaselowsky E.

1898

9410 Faber A.C.
10332 Croft J.P.
10332 Coomber G.
11923 Edwards E.
15814 Risbrough E.W.
16092 Theiss W.
16092 Nagel A.
20666 Whitehead J.
22759 Collins J.
25737 Tower B.

1899

2655 Thompson W.P.
3587 Overklift J van
14264 Boulton A.J.
14770 Wallace J.
24211 Gustine F.J.
24211 Walshe B.T.
24639 *Thompson W.P.
25327 Poteet A.E.
25327 Lobb J.W.

Note many of these early patents are to various kinds of top.

* Similar to Bohnenberger's original device.

**Similar to Serson's famous gyroscope sextant. See also GB. Patent specification 3785 of 1907.

7. THE FREE GYROSCOPE

7.1 The free Gyroscope (Free motion of the Gyroscope)

7.1.1 Authors

Okuner B.N. (1951)
Pel'por D.S. (1958)
Zhuravlev V.F. (1973)
Wrigley W Hollister W.M. Denard W.G. (1969) p.264 re Limited 'Free'
Gyro.

7.1.2 See G.B. Patent Specifications

581891
892453 page 2 lines 3-14
1213407
1284195
1399607

7.1.3 See U.S. Patent Specifications

2934960
3077785
3142183
3226984
3260122
3354726

8. GYROSCOPIC PENDULUM

8.1 Gyroscopic Pendulum
(Pendulous gyroscopic systems)

8.1.1 Authors

Andreev V.D. i (1965)
 Arnöld R.N. & Maunder L. ii p306 (1961) p339 p129
 Bocharov A.F. et al (1985)
 Bodewadt U.T. (1940)
 Bulgakov B.V. ii (1946)
 Bulgakov B.V. iv v 1939/1960 (pages 11.21.47.88.200)
 Chelnokov Yu. N. (1983)
 Corset M (1973)
 D.G.S. (1839)
 Gray J.G. v 1934
 Gruy L.J. ii (1878)
 Gruy L.J. v (1879)
 Firdlender G.O. and Kozlov M.S. (1961)
 Ishlinskii A. Iu. i. iv. v. (1956. 1957. 1957.)
 Ishlinskii A. Yu et al (1985)
 Karpachev. Yu. A & Korenevskii D.G. (1979)
 Klimov D.M. iv (1964)
 Kolmanovskii V.B. (1976) (see example 2. p736)
 Kondorskii I.D. (1970)
 Koshliakov V.N. viii (1975)
 Kukhlento A.I (1971) p267
 Kuznetsov V.M. et al (1985)
 Merritt E. (1897)
 Savet P.H. (1961)
 *Schuler M. ii (1923) p84
 *See U.K. Patent Specifications

108677
 221200

See U.S. Patent Specifications

1480637
 1735058

Tkacher L.I. (1949)
 Trayner B.T. (1977)
 Vol'fson G.B. Rivkin S.S. Til. A.V. (1973)
 Wrigley W. et al (1969) (p119-126) (p210-229)

8.1.2 G.B. Patent Specifications

11864 of 1913	220726	615734	945302
23001 of 1913	229403	640562	1428908
8760 of 1915	275649	664515	2036311
113659	291047	707446	2056062
125090	382343	752828	2111202
126395	371235	808447	
133067	398311	911842	

Pendulums damped by gyroscopic action

4131-1912	131979
2294-1913	243316
8760-1915	641360
10255-1915	
105753	

8.1.3 U.S. Patent Specifications

1480637	3011350
1651845	3162052
1735058	3172213
1880994	3229376
1906719	4266431
1940387	4648284
2432430	

See German Offenlegungsschrift 1941808

9. THE DIRECTIONAL GYROSCOPE

9.1

9.1.1 Authors

Firdlender G.O. and Kozlov M.S. (1963)
 Grammel R. (1950) Vol 2 p189
 Lequoc S. et al (1973)
 Riethmüller H. (1978)

9.1.2 G.B. Patent Specifications

411921	471895	518846	579991
434364	475321	525698	599248
437791	477012	549572	601964
453238	479243	550769	790019
453259	479279	565246	1513770
463332	495431	568692	
463396	507407	576524	

9.1.3 U.S. Patent Specifications

See. 3559493
 1096253
 2315216
 3321980
 2451230
 4483207
 4558604

*Directional gyroscopes —
 Erecting torques applied by ball, globules and like solid and liquid masses
 moving under gravity.*

645896	921562
802340	924744
808075	1297429
829169	
831336	

*Directional gyroscopes —
 Erecting torques applied by eddy currents*

359071
 740796

*Directional gyroscopes —
 Erecting torques applied by electric motors*

595990	777021	997469	1278894
601656	802340	1019343	1297429
623356	808075	1030706	1484793
645896	829169	1058291	1491953
654658	921562	1095131	1497065
680944	924744	1111676	1513770
729672	935976	1126463	1579920
751018	964763	1225674	

*Directional gyroscopes —
 Erecting torque applied by magnetic effects*

549572
 566887
 630657
 713357
 740796
 1029012

*Directional gyroscopes —
Erecting torques applied by unclassified means*

1010343
1058780
1207660
1225074

*Directional gyroscopes —
Unclassified features of*

29082-1912	422116	839024	1379642
129724	497584	862065	1428908
132839	499861	1055334	1486189
173541	559895	1083157	1513770
213791	582329	1111676	1579920
303245	654658	1278794	2002116
303817	681926	1330550	2107460
333874			

*Directional gyroscopes —
With means for re-setting gyroscope (other than scale only)*

129724	471835	777021
419816	477012	886728
434364	479243	1111676
464263	497584	1456883
471217	521160	

10. GYRO VERTICAL GYRO HORIZON

10.1 Function and Basic Arrangement

10.1.1 Authors

Arnold R.N. Maunder L. (1961) Chapter 12 P. 306-343
 Bulgakov B.V. and Roitenberg Ya N. (1948)
 Burdakov S.F. (1971)
 Firdlender G.O. and Kozlov M.S. (1963)
 Kliger L.I. Parusnikov N.A. (1966) (see pages 122-125, 210-229)
 Hector F. (1968)
 Monaco S.J. et al (1978) (note gyroless systems)
 Pinelis R.G. (1970)
 Rivkin S.S. Tyumeneva G.V. (1974)
 Roitenberg E. Ya. ii (1946)
 Wrigley W. Hollister W.M. Denhard W.G. (1969)

10.2 Errors

10.2.1 Authors

Boichuk O.F. iii (1962)
 Chelpanov I.B. ii (1962)

10.3 G.B. Patent Specifications directed to the gyro vertical in general

18133 of 1893	417185	555177	620149
4891 of 1914	421079	556264	621018
3318 of 1915	435353	558276	623078
13280 of 1915	435355	558684	623080
14032 of 1915	437861	565599	624408
108677	441130	570242	624564
123438	441439	573251	625288
127703	462826	573710	626634
128345	463332	573743	626635
129727	464193	575164	629364
130143	470311	575281	633942
130697	473148	577209	633954
133714	474629	579822	636545
141477	486315	580248	637993
147062	492184	581750	639803
151154	492670	582301	640562
161595	492707	583068	640632
173839	501945	584147	641360
177772	502462	590682	643613
186655	504726	591400	643749
193397	512355	592500	645332
221006	517587	593963	648492
221200	522207	598470	651261
239043	525876	599607	655536
261117	528569	599665	655823
274268	530549	601447	656889
274980	534870	603427	660930
281694	535160	603711	660208
291047	537137	605058	664065
315966	538547	605955	666432
316380	542565	607349	666615
322098	542963	607353	668310
344239	545284	608782	671411
345127	545694	608851	675048
361836	546504	610554	675860
364625	548190	612507	678242
379134	548376	612608	678768
390410	549572	615734	682528
393695	551079	617055	683777
401039	551245	619939	686862
415277	552554	619945	698295
416813	553344	619960	701385

707660	763750	863457	1157966
712888	772005	863458	1162305
716779	777021	871147	1162318
717349	776845	876865	1166692
720220	777698	878891	1172441
724428	777818*	882321*	1197253
726627	784473	911842*	1207336
726849	790019	917168	1231069
726890	790031	942060	1244549
729518	791556	944828	1247785
729946	798107	945302	1270567
731737	801550	960818	1284700
733024	805947	990701	1297429
734148	808447	990740	1301781
737236	821416	996283	1346558
740681	821417	1009506	1411201
741773	824101	1034135	1477603
741960	826418	1040004	1506180
745186	834724	1042940	1513770
747621	835650	1049794	1536316
751018	842901	1065624	1536344
751148	843446	1108293	2023817
752828	854506	1108614	2031149
753258	856685	1126463	2066952
753333	860171	1126611	2155632
760251*	863456	1134273	

10.4 U.S. Patent Specifications directed to the gyro vertical in general

2378858	2595268	2999390	3604275
2411087	2786357	3077787	4158312
2492992	2893248	3272017	4197655
2505021	2919586	3285077	4088031
2515200	2945381	3466935	4297905

10.5 G.B. Patent Specifications directed to Erectors for the Gyro Vertical

130697	588537	660208	831336
132944	591626	661816	842089+
166800	591768	671861	844535+
441130	593733	678768	847964
441439	597282	682528	852591
490724	601444	686862	892050+
492670	601656	706494	896378
492707	602235	718124+	911871
517587	603158	734148	919386+
538574	604224	737534	930317
555321	604734	755326	964763
559979	606595	756504	1042940
560478	611004	761521	1108614
564484	619945	794508+	1126463
573061	619960	798336	1137523+
573743	620149	802340	1162318
573772	623356	808075	1243236
576524	633954	811036+	1398905
580248	636123	814919	1398906
583902	649276	829169	1405275

10.6 G.B. Patent Specifications directed to Inclometers

134234	246741	393695	471895
136168	309150	426185	473688
140482	309546	442911	475097
145460	341519	445586	485043
145465	351672	463114	485044
160316	392163	471093	487952

*(A teaching dissertation with mathematics!)

489232	561018	655138	826804
499861	596666	666432	882795
510524	601971	670002	919386
511742	609475	726627	1111456
515176	610855	758733	1173564
532960+	625415	769247	
544786	633942	777698	
553730	641137	785399	

10.7 G.B. Patent Specifications directed to Deviation Indicator Attitude Reference

411921	1224825
893313	1288290
1132851	1297429
1134273	1301781
1195487	1323864

10.8 G.B. Patent Specifications directed to Gyro Verticals — erecting torques applied by air and other fluid jets

145460	511742	556262	602235
166906	512355	559979	606595
220726	517587	564484	607353
242093	522384	573061	611004
365188	547208	581891	661816
393354	549042	583902	733058
426185	549944	588537	1277680
483370	551073	591768	1283819
490724	555177	599607	

10.9 G.B. Patent Specifications directed to Gyro Verticals erecting torques applied by auxiliary gyroscopes

581891
619960
656889
1204763

10.10 G.B. Patent Specifications directed to Gyro Verticals erecting torques applied by balls, globules, and like solid and liquid masses moving under gravity

14032-1915	555321	620149	718124
125690	564484	623356	720200
130697	573743	633954	726849
132944	573772	645408	726890
161595	581981	649276	731737
166800	584147	655523	737534
173839	591020	657668	751403
401039	592500	657670	755326
441439	601444	660203	756504
532900	603158	661816	761521
534870	604224	675048	777818
535160	605455	675860	794508
542963	608851	683777	798336
545190	619945	698295	798485

10.11 G.B. Patent Specifications directed to Gyro Verticals — erecting torques applied by eddy currents

402890	636123
441439	637993
492670	651261
552554	740796
624564	1580092

10.12 G.B. Patent Specifications directed to Gyro Verticals erecting torques applied by electric motors

11864-1913	558276	608851	619960
239043	583902	611030	623356
548190	593733	612608	637993
552554	597282	619945	639803

640562	720220	808447	1126463
643749	726890	810440	1132851
645332	731737	811036	1137523
655823	732975	814919	1166692
656889	733058	842089	1204763
657668	740681	842901	1207336
657070	745186	844535	1224512
660208	751018	886305	1297429
661816	751403	892050	1398905
671260	753258	902489	1398906
675861	755326	935976	1405275
673242	756504	940790	1411201
682525	760251	942060	1484793
683777	761521	960818	1506180
686362	777021	964763	1513770
706494	777818	1010343	
718124	798336	1051905	

10.13 G.B. Patent Specifications directed to Gyro Verticals erecting torques applied by magnetic effects

309150	517587	601447	660208
345127	545694	602235	671861
378148	547208	605955	732975
464193	549944	612608	740796
468288	592500	615734	756504
501945	593733	619939	798107
510524	601444	654041	

10.14 G.B. Patent Specifications directed to Gyro Verticals erecting torques applied by masses controlled by solenoids

173839
186655
584147
645332
834724
1065624

10.15 G.B. Patent Specifications directed to Gyro Verticals erecting torques applied by unclassified means

108677	211200	382343	847964
126395	261117	401039	856685
127703	274268	402890	871147
134234	282633	633942	1010343
141477	291047	645332	1204763
166800	309546	649704	1207336
173839	316380	734148	
186655	379134	839024	

10.16 G.B. Patent Specifications directed to Gyro Verticals erecting torques increased temporarily

51787	726849	761521	842089
597232	726890	798336	892050
623356	731737	814919	
675048	751403	842089	
675860	756504	814919	

10.17 G.B. Patent Specifications directed to Gyro Verticals means compensating for or preventing acceleration effects (e.g. during turning)

134234	364625	551079	615734
141477	393695	551245	619939
161595	492670	558086	619960
166800	501945	565599	624564
173839	512355	581891	637993
186655	525076	583902	639803
221006	528569	593963	640562
261117	530549	602235	655823
309150	538574	603955	656389
345127	548190	611004	678242

683777	777818	871147	1162318
686862	792346	902489	1166692
698295	798485	911871	1297429
706494	808447	930317	1405275
720220	811036	942060	1484783
737534	812294	944828	1506180
755326	834724	960818	1513770
760251	842901	964763	
769247	844535	1040004	

10.18 G.B. Patent Specifications directed to Gyro Vertical unclassified

261106-1911	468672	718124	1018679
125791	522384	756504	1247735
127007	549042	810440	1277680
378148	553730	852591	1283869
382343	599665	902489	1323864
426185	643492	944823	

10.19 G.B. Patent Specifications directed to rate of turn indicators

5821-1911	455514	636952	917452
11331-1911	457483	641360	918197
125096	471093	654041	918524
129307	471537	656518	924218
130095	475097	656889	924968
131992	476013	659659	926100
133714	476033	662834	926959
137060	485043	670983	928487
139771	488601	677306	931398
147271	439232	683777	932173
149100	407952	684667	933251
151154	508213	684668	935905
152008	510524	686862	939622
162304	511196	687135	945302
164396	515176	698031	945800
171513	518817	698032	955057
181164	521160	698033	960437
186159	523947	708969	964648
191676	526360	712923	971984
196296	530222	716871	973122
196831	535270	729241	977873
213023	535966	740796	978029
217405	549105	753127	983658
218953	553650	767069	987921
246741	553730	772849	1015681
248583	554164	778680	1021801
292051	561018	784576	1023554
294691	562886	785399	1042940
301278	572201	792630	1054238
331627	572213	815556	1056557
337295	579909	839770	1056819
340327	582541	842775	1061769
341519	587631	845808	1074357
351672	587719	847278	1083157
361836	587897	854360	1085498
371235	591182	872777	1086539
373832	592645	874563	1095519
382752	599149	875754	1096831
387366	599412	878029	1097682
389819	603383	879683	1108391
391111	604208	886391	1121117
392163	612571	889864	1146833
413715	616374	895064	1160039
415277	617108	898595	1163017
422116	618456	900138	1171719
425890	625869	911355	1173647
428533	627123	911913	1189631
442991	629462	914128	1271728
445586			

1310525	1508302
1330550	1525116
1357020	1540279
1410580	1545774
1414297	2005411

10.20 G.B. Patent Specifications directed to Gyroscope apparatus kind or types — unclassified

8952-1912	331956	938957	1093550
24518-1912	435353	945387	1109615
5365-1913	565872	953585	1109634
16099-1913	599826	983586	1129294
941-1914	622337	964446	1129295
114441	635192	964447	1144880
142261	636117	1008765	1160039
145459	637505	1016260	1160528
160868	757678	1023554	1203841
166906	805535	1034314	1260617
170864	826419	1051213	1388082
172029	826420	1073446	1535174
177772	885946	1078356	1538069
187490	885947	1078357	1570304
187985	900933	1078358	
247633	904570	1093549	

10.21 U.S. Patent Specifications directed to specific features of the Gyro Vertical

10.22 Gyroscope Control Erecting

1310862	2678564	2949786	3350947
1311768	2699681	2969683	3359807
1380336	2715709	2973651	3387482
1442799	2716894	2988923	3466935
1736039	2728233	2995039	3495465
1906719	2732721	3051006	3533297
1931191	2740961	3056304	3575093
2087961	2803965	3157053	3576134
2161241	2821087	3190131	3614895
2190698	2823545	3193220	3635003
2242806	2828628	3203261	3640137
2297265	2841017	3205719	3727467
2344126	2848898	3226986	3811329
2411087	2875619	3242744	3931747
2418032	2878678	3252340	3954024
2425300	2879668	3258978	3985320
2427130	2887783	3267745	4074580
2427549	2897676	3276269	4283960
2463095	2906127	3285077	4383452
2592582	2913907	3301074	
2656727	2916919	3329028	

10.23 U.S. Patent Specifications directed to Gyroscope Control erecting by plural diverse forces

2380941	2592092	3588001	4149618
2417066	2676491	3638502	4346614
2417081	2720116	4020491	
2435581	2916918	4061043	
2567948	3582018	4068533	

10.24 U.S. Patent Specifications directed to Gyroscope Control erecting by jet

RE22003	1512222	1805854	1982637
1096254	1518892	1866706	1984859
1173241	1563934	1903710	1996895
1197134	1644921	1934774	2009263
1291695	1651845	1939825	2011738
1324482	1677331	1982635	2015650
1442799	1773411	1982636	2035538

2036229	2311652	2504166	3492879
2044151	2314343	2514426	3498145
2044343	2315500	2602334	3498476
2086896	2323244	2609239	3499335
2091963	2324157	2628502	3503269
2091964	2326784	2635469	3511101
2093417	2327623	2708369	3516280
2099705	2340768	2722570	3525159
2126855	2344112	2780104	3531998
2129586	2344126	2916918	3597984
2133489	2348235	2923161	3606794
2133793	2363495	2937804	3610053
2140191	2363500	2997886	3612443
2159099	2366543	3012440	3667301
2174777	2366707	3093004	3673875
2180221	2368058	3139758	3677098
2183939	2369131	3152486	3747418
2207717	2373120	3162053	3827361
2210916	2375764	3241378	3933096
2219243	2380932	3272019	4000660
2219295	2380941	3301069	4046316
2225568	2385342	3310987	4069990
2226191	2395251	3319475	4088031
2227529	2408044	3323376	4147066
2242233	2409188	3362233	4150579
2242806	2420674	3416378	4158312
2248141	2425300	3435688	4291849
2249744	2445388	3438269	4297905
2257730	2446180	3451289	4527439
2292989	2486578	3457793	4553440
2293707	2492057	3465600	

10.25 U.S. Patent Specifications directed to Gyroscope Control erecting by weight

877034	2198551	2464516	2789436
1148721	2300548	2479304	2817239
1308692	2326784	2480263	2842968
1309637	2348604	2499238	2875854
1311768	2351619	2499391	2878679
1324478	2356749	2501885	2886972
1405807	2368644	2504061	2895339
1442799	2370904	2505686	2916918
1446280	2373120	2511273	2919586
1524709	2380941	2530154	2934962
1559688	2384838	2534463	3094054
1586525	2392370	2556097	3147628
1527178	2408411	2572733	3157053
1634140	2427130	2573426	3347104
1736039	2427158	2592643	3357263
1763806	2434488	2603095	3358515
1773172	2435090	2603767	3498146
1801619	2438213	2620669	4275604
1801947	2439418	2625825	4294128
1811415	2441307	2697354	4346614
1866706	2445384	2711652	4354394
1866732	2446727	2720116	4377950
1988463	2457150	2722839	
2159188	2462541	2756598	

10.26 U.S. Patent Specifications directed to Gyroscope Control erecting by friction

1096253	2412481	2441157	2871705
1308783	2417066	2457150	3304789
1435580	2422120	2485953	3469350
1825345	2422267	2722126	3424523
1942470	2423270	2722127	3559493
2386176	2428925	2734385	3703832
2404603	2435581	2828629	

10.27 U.S. Patent Specifications directed to Gyroscope Control erecting by Magnetic Field

363184	2409188	2695165	3458239
381604	2412204	2716345	3469458
877034	2417573	2731836	3490297
1136566	2418032	2756598	3498146
1310862	2419063	2822694	3524356
1390471	2441157	2829557	3526145
1529720	2449661	2846891	3678765
1571658	2450320	2856240	3741020
1589039	2466248	2900825	3754475
1736039	2468113	2908171	3845995
1985082	2473516	2912864	3858328
2109953	2486897	2916919	3988658
2126855	2488358	2933925	4008623
2167422	2492995	2951373	4036428
2175631	2509446	2951374	4093154
2188606	2510968	2951377	4167296
2225032	2513329	3025708	4170904
2229645	2519459	3082628	4185797
2238645	2524512	3107540	4189948
2247142	2525108	3130591	4191346
2270876	2534824	3237055	4211452
2278379	2548918	3242745	4240302
2297265	2552132	3251233	4259871
2328744	2585693	3252340	4285248
2339606	2598355	3273404	4285552
2360339	2600476	3276273	4290316
2365439	2605641	3283594	4296639
2368644	2620669	3301072	4316394
2378858	2625678	3327541	4320669
2384761	2630016	3362232	4357837
2390532	2630017	3371332	4380108
2397949	2676491	3373617	
2406845	2679366	3424523	

10.28 U.S. Patent Specifications directed to Gyroscope Control erecting by Motor Torque

1223375	2429605	2625046	2875619
1228061	2429612	2630015	2878445
1236993	2446180	2630017	2879671
1324128	2469782	2633029	2879672
1446348	2470773	2634391	2880617
1556620	2472824	2645942	2880618
1679354	2474549	2662411	2895339
1801329	2477574	2667705	2900825
1840104	2497614	2679366	2900826
1923290	2516912	2685207	2907213
1942737	2517786	2720116	2908171
2191997	2528487	2737054	2911832
2220055	2531826	2740299	2911833
2270875	2533217	2745288	2912766
2293092	2542975	2763157	2926530
2297719	2551069	2771779	2929250
2315167	2553268	2800025	2936628
2357319	2567948	2804776	2940318
2367465	2577912	2817975	2947177
2368628	2581476	2824451	2948813
2381438	2586469	2825229	2951373
2382993	2588607	2834215	2960878
2386176	2589874	2835132	2968957
2389158	2597151	2836071	2969683
2397949	2598672	2841987	2972893
2401337	2603094	2846890	2986946
2409634	2607231	2846891	2992563
2409659	2608099	2854851	2995040
2410473	2608867	2857677	2998727
2412614	2608868	2863014	3009361
2414291	2608869	2868024	3015962

3020770	3238791	3371542	3979090
3018044	3238795	3415126	4063141
3051007	3258978	3431786	4161884
3077787	3267745	3438270	4197655
3079696	3276273	3456513	4255979
3082631	3279086	3534616	4267737
3160019	3301072	3604276	4281555
3161066	3301074	3657918	4283960
3167763	3318161	3702569	4292854
3293261	3327541	3703822	4383452
3225607	3354728	3705977	4395922
3234799	3368411	3763709	

11. THE DIFFERENTIATING GYROSCOPE

(Gyroscopic spin-rate meter to determine angular velocity of rotation of a vehicle around any one of its main axes. In certain aircraft differentiating gyroscopes are used *inter alia* in yaw, pitch and roll. On certain satellites, differentiations gyroscopes can be used for damping oscillations with respect to its centre of mass).

11.1 Introduction

11.1.1 Authors

Alexsandrov A.G. (1975)
Firdlender G.O. and Kozlov M.S. (1961)
Luetzkendorf R. (1972)
Nikitin E.A. and Balashova A.A. (1969)

11.2 Gyroscopic Tachometers

11.2.1 Authors

Maksimov V.V. (1963)
Pavlovskii M.A. et al (1976)

11.3 Gyro-accelerometers

11.3.1 Authors

Corset M. (1973)

11.3.2 G.B. Patent Specification

1160039

11.3.3 U.S. Patent Specification

4651565

11.4 Vibratory Gyroscopes

11.4.1 Authors

Diamantides N.D. (1959)
Sorg H. ii (1968)

11.4.2 G.B. Patent Specifications General

7285 of 1910	218953	508213	625869
22188 of 1911	248583	511196	627123
125096	271528	521160	629462
129307	292051	530222	636952
130095	301278	535270	659659
131992	331627	535966	662834
137060	371235	544728	677306
139771	382782	551650	708969
145459	387366	554164	712993
147271	388169	562886	716871
149100	391111	573061	722492
152008	392163	579909	739589
160523	405513	582541	743251
162304	413715	587631	749990
164396	442291	587719	751018
170864	445586	587897	765675
171513	455514	591182	767069
181164	457483	592645	772849
186159	471093	599412	778680
191676	471537	604208	784576
196296	475097	611005	785399
196831	485043	612571	792630
213023	488601	616374	803722
217405	489232	617108	830915

839770	932173	1061769	1189631
847278	933251	1074356	1242786
865344	960437	1085498	1249128
874563	971984	1086539	1271728
876424	978029	1095519	1288118
879683	987921	1096831	1288449
886391	989101	1097682	1306792
889864	1021801	1102477	1310524
895064	1023554	1121117	1357020
898595	1029012	1121750	1410580
900138	1049794	1125931	1414297
911913	1054082	1125932	1508302
914128	1054238	1146833	1525116
924968	1056557	1160039	2005411
926100	1056819	1172441	

11.4.3 U.S. Patent Specifications rate of turn

2189375	2839931	3187587	3902374
2291612	2839932	3214980	3925642
2581965	2839933	3303706	4061043
2687647	2839934	3444744	4068533
2719291	2986941	3466934	4179087
2800024	3009360	3487701	4445375
2815667	3065641	3529477	
2839930	3084559	3592066	

11.4.4 Russian Patent Specification

547693

12. THE INTEGRATING GYROSCOPE

The integrating gyroscope is a gyroscopic angular velocity integrator, used to determine the angle of rotation of an object by integrating the component of its angular velocity around the axis of measurement for use *inter alia* in auto pilots and navigational control systems.

12.1 Introduction

12.1.1 Authors

Firdlender G.O. and Kozlov M.S. (1963)
Haeussermann W (1962)
Nikitin E.A. and Balashova A.A. (1969)
Wrigley W. (1963)

12.2 Rate-Integrating Gyroscope

12.2.1 Authors

Arutyunov S.S. i ii iii (c.1960)
Draper C.S. et al (1956)
Goodman L.E. and Robinson A.E. (1957)
Horath W.K. (1959) See. French Patent. 1224158 corresponds to GB. 911913 US. 3084559
Koval V.A. and Andreichenko K.P. (1978)

12.3 Gyroscopic Integrator of Linear Accelerations

12.3.1 Authors

Bogatskaya I.G. et al (1973)
Sinitsin I.I. (1967)
Sinitsin I.N. (1969)

12.4 Miniature Integrating Gyroscope

12.4.1 Authors

Durkee R.P. (1962)

12.4.2 G.B. Patents Specifications

130095	662334	889898	1021801
269280	628123	911913*	1056557
299407	753449	924968	1109615
443051	761069	945387	1254385
414718	790637	953585	
504753	803722	953586	
559327	854393	980437	

12.4.3 U.S. Patent Specifications

2709922	2964956	3725607
2752791	2968940	3339421
2819053	3000223	4005603
2951207	3084559	4087919
2954700	3084560	4461175

*Equivalent to French 1224158 translated into English early, in OTS US Report 6218919)

13. TYPES OF MODERN GYROSCOPES AND THEIR CONSTRUCTION

13.1 Asymmetrical gyroscope

13.1.1 Authors

Anchev A. ii (1964)
 Grammel R. iii (1960)
 Grioli G. iv (1963)
 Klimov D.M. ii (1959)
 Leipholz H. ii (1963)
 Leppert von M. (1983)
 Lukach I. and Smorodinskii Ya. A. (1974)
 Magnus K. viii (1955)
 Mettler E. (1973)
 Smirnova E.P. i (1974)
 Vlasov Yu. B. (1974)
 Zhuravlev V.F. iii (1976)

13.1.2 G.B. Patent Specifications

No Entries

13.1.3 U.S. Patent Specifications

2991659
 3191445
 3805625
 4445375

13.2 Free Rotor Gyroscopes

13.2.1 Authors

Drew T.A. and Carnaghie J.A. (1968)
 Savet P.H. ii (1963) (definition p.46)
 Slater J.M. iii (1962)
 Zedekar S.J. (1968)

13.2.2 G.B. Patent Specifications

141139	1015153	1304571	1514228
471217	1066914	1305571	1514780
580680	1084280	1312294	1520139
722492	1150532	1356667	1522138*
937444	1160295	1364757	1589789
961285	1244519	1399607	1589790
973629	1284195	1514227	

13.2.3 U.S. Patent Specifications

1589039	2785573	3081552	3557629
1972882	2841760	3115784	3673872
1986807	2857767	3142183	3677097
2086897	2871703	3149276	3678764
2133809	2919583	3164022	3706231
2142018	2959060	3211011	3943778
2377175	3003356	3214981	3954024
2434251	3004683	3232120	4000660
2474072	3005117	3250135	4030371
2562690	3025708	3251233	4189948
2691306	3037170	3354726	4217787
2704401	3044309	3358514	4240301
2719291	3056303	3529477	4296639
2729106	3077785	3537324	

*(A mathematical dissertation on the subject).

13.2.4 French Patent Specifications

926351
1336096
2219702

13.2.5 European Patent Specifications

EP 0009347
0023958

*13.3 One Degree of Freedom Gyroscopes

13.3.1 Authors

Andersen J.P. (1968)
Ausman J.S. ii (1963)
Clark R.N. (1974)
Joos D.K. (1977)
Koning M.G. (1977)
Pitman G.R. and Goodson R.E. (1963)
Wrigley W. (1963)
Vasil'ev V.N. (1983)

13.3.2 G.B. Patent Specifications

722492	973122	1172441	2064116
753127	980487	1189631	2135775
753449	1037756	1304571	2151783
772849	1068426	1306792	
960437	1129294	1456883	
971984	1129295	1557528	

13.3.3 U.S. Patent Specifications

1940387	3104553	3362232	3974702
2809526	3131569	3496781	4627737
2855782	3142182	3570281	4633722
2986943	3247725	3608383	
3060752	3250134	3885443	

13.4 Two Degree of Freedom Gyroscopes

13.4.1 Authors

Ausman J.S. ii (1963)
Barnett D. (1964-65)
Briggs R.W. (1965)
Cockin I. (1963) (page 36)
Gubbins H.L. and Barkel D.J. (1974)
Kargu L.I. Yablonskaya V.A. (1976)
Read R.S. (1963)
Savet P.H. (1961) (1963)
Willems P.Y. (1974)
Zhou-Heng (1979)

13.4.2 G.B. Patent Specifications

684668	1084456	1160039	1436941
722492	1089070	1201828	1506180
885303	1103490	1239176	2012998
896728	1103495	1269054	2151783
925219	1104525	1283118	
950694	1141385	1289600	
1083157	1155545	1304571	

13.4.3 U.S. Patent Specifications

1192532	3115784	3263507	3489018
1639233	3131569	3263508	3902374
2098564	3165282	3267747	4189047
2677194	3182514	3323375	4212443
2742299	3186241	3354726	4498340
2872821	3187588	3362231	4320669
2959059	3214981	3408874	4255979
2995938	3225609	3416378	4361760
3065641	3247726	3438269	
3077785	3257854	3483760	

13.4.4 European Patent Specifications

EP.0122745

13.5 Low Wander Gyroscope

13.5.1 Authors

Wrigley W. et al (1969) see p 267 Re. Lord Bowdoin's low wander gyroscope

13.5.2 G.B. Patent Specifications

No Entries

13.5.3 U.S. Patent Specification

3765250

13.6 Floated Gyroscopes

13.6.1 Authors

Anon (1971)
 Barnaby R.E. et al ii (1961)
 Chizhikov V. Yu et al (1974)
 Cochlin I. (1963) See p 44
 Coldwell T et al (1964-1965)
 Cuny B. (1965)
 Daw H.A. (1965)
 Falk R.A. and Muller F. von (1960)
 Gorodetskii O.M. (1977)
 Johnston W.D. and Toda N.F. (1960)
 Lewellen W.S. (1966)
 Osband S. (1962)
 Savet P.H. i 1961 see p 282
 Slomianskii G.A. and Pryadilov Yu. N (1958)
 Swanson C.O. (1962)
 Wrigley W. et al (1969) See p 257. 262
 Vechtomov V.M. (1972)

13.6.2 G.B. Patent Specifications

722492	852562	926959	1084456
740349	856374	941317	1117848
740350	867867	958988	1167286
753449	867868	971984	1244519
772432	878028	990701*	1456883
802776	878939	992535	1545116
815556	885303	1025325	1554205
840395	886391	1037756	
845808	889358	1056557	
847278	911913	1083157	

*Mathematical dissertation

13.6.3 U.S. Patent Specification

794654	2854850	3104553	3250134
1180815	2856776	3126747	3323374
1480637	2857767	3127776	3353413
1501886	2859626	3132523	3396587
1589039	2865206	3164022	3401567
2307590	2896455	3214982	3402610
2393473	2898765	3225607	3526144
2613538	2900822	3230778	3570281
2618159	2928281	3232120	3657931
2625045	2928282	3237458	3722297
2644727	2964950	3238792	3885443
2649808	2986941	3240074	3886803
2729107	2995937	3240076	3974702
2785573	3020768	3242742	4448086
2817974	3084559	3262324	

13.6.4 French Patent Specification

1224158

13.7 Gas Bearing Gyroscopes

13.7.1 Authors

Anon (1971)
Beardmore G. (1985)

13.7.2 G.B. Patent Specifications

937444
986485
1017590
1084280
1150134
1197646

13.7.3 U.S. Patent Specifications

1544443	2670146
2986896	2683635
2582788	2696410
2597371	3048043
2627443	3807239

13.8 Electrostatic Gyroscopes

13.8.1 Authors

Andrews A. (1973)
Belitskii A and Martynenko Yu. G. (1977)
Cochin I. (1963) See p 52
Gubarenko S.I. and Martynenko Yu. G. (1982)
Knoebel H.W. (1964)
Koretskii A.V. Martynenko Yu. G. (1983)
Koval S.T. et al. (1972)
Kudin S.F. and Martynenko Yu. G. (1985)
Martynenko Yu. G. (1970)
Martynenko Yu. G. and Medvedev A.V. (1985)
Medvedev A.V. (1985)
Nordsieck A. (1962)
Slater J.M. iii (1962)

13.8.2 G.B. Patent Specifications

992535	1314304	1525116
1013275	1324458	2166867
1051022	1343690	2175692
1181704	1362149	
1273522	1368037	

13.8.3 U.S. Patent Specifications

2552050	3262325	3482455	3965753
3003356	3262326	3495465	4061043
3024364	3262327	3496780	4068533
3098676	3274666	3847026	4074580*
3098679	3295379	3902374	4587860
3148456	3379070	3906804	4654582
3198021	3451274	3954024	

13.8.4 European Patent Specifications

EP.0121483
EP.0128066
EP.0174408

13.9 Magnetically supported Gyroscopes (Magnetic Gyro, Electromagnetic Gyro)*13.9.1 Authors*

Arrighi G. (1947)
Cochin I. (1963) see p 56-66
Crova A. (1882)
Martynenko Yu. G. (1973)
Miller J.W. (1976)
Musatov K.A. Rudenko V.M. Filatov V.V. (1986)
Parente R.B. (1969)
Sidyakov D.F. (1975)
Urman Yu. M. (1984)

13.9.2 G.B. Patent Specification

1167286

13.9.3 U.S. Patent Specifications

1864801	2809526	3316032	4114452
2377175	2822694	3344676	4355541
2436939	2919583	3475975	4643034
2562690	3146038	3473852	4651565
2691306	3112962	3565495	
2695165	3196694	3777255	
2733857	3225608	4114451	

13.9.4 German Patent Specifications

2751040
2755318

13.9.5 Russian Patent Specification

439879

13.10 Torsion supported Gyroscopes*13.10.1 Authors*

Wrigley W. et al (1969) see p 266

*Extensive earlier art cited

13.10.2 G.B. Patent Specification

1160039

13.10.3 U.S. Patent Specifications

Re issue 24880

2919585

3009360

3430276

4259871

13.11 Reversing Gyroscopes

13.11.1 Authors

No Entries

13.11.2 G.B. Patent Specifications

No Entries

13.11.3 U.S. Patent Specification

3078727

13.12 Bootstrap Gyroscope

Defined as any type the drift of which decreases nearly to zero if the main frame thereof is maintained in nearly perfect alignment with the rotor axis.

13.12.1 Authors

No Entries

13.12.2 G.B. Patent Specifications

884061

1017590

13.12.3 U.S. Patent Specification

2940318

13.13 Dynamically Tuned (free rotor) Gyroscopes

13.13.1 Authors

Beardmore G. (1985)

Bennett G.S. (1947)

Bonfield D.G. (1977)

Craig R.J.G. (1972)

Dewar D.M. Cooke D.D. (1976)

Ebert W. (1976)

Haberland R. (1977)

Howe, E.W. et al (1964)

13.13.2 G.B. Patent Specifications

599826

1142848

1511430

2963471

1058780

1274599

1514780

2081522

1078356

1315432

1522138

2083910

1093549

1378946

1541330

2163849

1142846

1446112

1553488

2178851

1142847

1481839

2042723

13.13.3 U.S. Patent Specifications

2517612	3505882	3832906	4563909
2581965	3512419	3943778	4592242
2940313	3524355	3974701	4596158
3301073	3678764	4126046	4655096
3354726	3678765	4257280	
3367194	3700290	4357837	
3477298	3702568	4499778	

13.13.4 German Patent Specification

953662

13.13.5 European Patent Specification

EP.0146850

13.13.6 Swiss Patent Specification

483620

*13.14 Precision Gyroscopes**13.14.1 Authors*

Barnaby R.E. (1959)
 Klemes M. Lane A.W.
 Zeigler E.J. (1959)

13.14.2 G.B. Patent Specifications

No Entries

13.14.3 U.S. Patent Specifications

2933925
 3003356
 3198021

13.14.4 French Patent Specification

1025771

*13.15 Two Axis Case Rotating Gyroscopes**13.15.1 Authors*

No Entries

13.15.2 G.B. Patent Specifications

950594
 973629

13.15.3 U.S. Patent Specifications

2577942	3327538
2924978	3498144
2970480	3540295
3182514	
3214981	

*13.16 Thermoelectrically Cooled Gyroscope**13.16.1 Authors*

No Entries

13.16.2 G.B. Patent Specifications

No Entries

13.16.3 U.S. Patent Specifications

3091919
3097027
3186240

13.16.4 European Patent Specification

EP.0142937

13.17 Single Degree of Freedom Miniature Integrating Gyroscopes

13.17.1 Authors

Swanson C.O. (1962)
Zholdak S.A.

13.17.2 G.B. Patent Specifications

1056557

13.17.2 U.S. Patent Specifications

2934961
3074283
3077760
3204467
3273405
4461176

13.18 Spherical Rotor Gyroscopes

13.18.1 Authors

Drew T.A. et al (1968)
Graham K.D. (1964)
Henriot E.J.C. and Haguenand E.A. i (1927)
Martynenko Yu. G. (1974)
Pittman W.C. (1962)
Urman Yu. M. (1973)
Vechtomov V.M. (1972)

13.18.2 G.B. Patent Specifications

378148	871147	1083157	1362149
383164	971984	1133605	1399607
483370	990701	1244519	1505519
733678	1016260	1314304	2166867
790019	1051022	1324458	

13.18.3 U.S. Patent Specifications

2740299	3252340	3451274	3906804
2959060	3274666	3482454	3915019
2968954	3379070	3482455	3918310
3154953	3339420	3496780	
3198021	3401567	3522737	
3252337	3402610	3880606	

13.19 Digital Rate Gyroscope with Vibrating Beam Force Transducers

13.19.1 Authors

No Entries

13.19.2 G.B. Patents Specifications

No Entries

13.19.3 U.S. Patent Specifications

2746301
2875618
3190129
3267746
3270566
3413859

13.20 Gas Lubricated Reaction Gyroscope*13.20.1 Authors*

No Entries

13.20.2 G.B. Patent Specifications

No Entries

13.20.3 U.S. Patent Specification

3482454

13.21 Double Rotor Pneumatic Gyroscope*13.21.1 Authors*

No Entries

13.21.2 G.B. Patent Specifications

No Entries

13.21.3 U.S. Patent Specifications

1984874	3186241
1996896	3446082
2273309	
2940318	
3043653	

13.22 Strap-down Gyro with Quartz Crystals*13.22.1 Authors*

No Entries

13.22.2 G.B. Patent Specifications

No Entries

13.22.3 U.S. Patent Specifications

2479122	3147627
2567682	3267746
2703935	3438268
2746301	3802276
2964952	

13.23 Two Axis Gimballess All-Attitude Hydrostatic Free Rotor Gyroscope*13.23.1 Authors*

No Entries

13.23.2 G.B. Patent Specification

1599082

13.23.3 U.S. Patent Specifications

3276270

3277304

3301071

3328595

3355953

3489017

13.24 Rate Gyro Using Elastic Restraint (fluid wedge)

13.24.1 Authors

No Entries

13.24.2 G.B. Patent Specifications

No Entries

13.24.3 U.S. Patent Specifications

3152845 3321199

3194613 3487701

3199931

3210848

3311987

13.25 Gyro with Vibrating Gimbals

13.25.1 Authors

No Entries

13.25.2 G.B. Patent Specifications

No Entries

13.25.3 U.S. Patent Specification

3678764

13.26 Hooke's Joint Gyroscopes

13.26.1 Authors

Arnold R.N. Maunders L. (1952)

Beardmore G. (1985)

Brosens P.J. Crandall S.H. ii (1961)

Burdess J.S. (1978) (1975)

Burdess J.S. Maunders L. (1972)

Hill A.T. (1967)

Filatov V.V. (1973)

Fogarasy A.A. (1974)

Fox C.H.J. Burdess J.S. (1978)

Porter B. ii (1961, 1962)

Porter B. Gregory R.W. (1963)

Ryan T.J. (1989)

Van Dijk G.H.M. (1972)

Shatalov M. Yu. (1985)

13.26.2 *G.B. Patent Specifications*

578958	1072926
732975	1378946
733058	1450027
838383	1522138
1058780	2007840

13.26.3 *U.S. Patent Specifications*

2527245	See 3748912
2909064	4529871
3080762	4587860
3290949	
3301073	

13.26.4 *German Patent Specification*

2818105

13.25.5 *European Patent Specification*

EP.0121483

13.27 Multiple-jet pneumatic gyroscope

13.27.1 *Authors*

No Entries

13.27.2 *G.B. Patent Specifications*

No Entries

13.27.3 *U.S. Patent Specifications*

2729106	3416378
3115784	3482454
3275270	361053
3320816	4553440
362231	

13.28 *Hydrostatically Supported Gyroscope with Combined Centrifuge and Viscous shear Rotary Pump*13.28.1 *Authors*

Cochin I. (1963)
See p 48, 50.

13.28.2 *G.B. Patent Specifications*

No Entries

13.28.3 *U.S. Patent Specifications*

3267744
3321979
3643516
3653267
3657930
3662609

13.29 Two Axis Rate Captured Saturn Rotor Gyroscope

13.29.1 *Authors*

No Entries

13.29.2 *G.B. Patent Specifications*

No Entries

13.29.3 U.S. Patent Specifications

3252340	3722295
3260475	3902374
3262324	
3413859	
3611815	

13.30 Vented Rotor Gyroscope

13.30.1 Authors

No Entries

13.30.2 G.B. Patent Specifications

No Entries

13.30.3 U.S. Patent Specifications

2964953	3877317
3107588	3878730
3604277	
3610053	
3726572	

13.31 Universal Gyroscope

13.31.1 Authors

No Entries

13.31.2 G.B. Patent Specifications

No Entries

13.31.3 U.S. Patent Specifications

1864601
1954998
2688805
2809527

13.32 Fluid Rotor Magneto-hydrodynamic Gyroscope

13.32.1 Authors

Carrier G.F. Miles J.W. ii (1964)
Diamond H.B. i (1967)
Egli W.H. (1964)
Fiebig M. (1966)
Jaumann J. (1932)
Kastrov V.V. Rogovoy V.M. (19620)
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Wing W.G. ii (1963)

13.32.2 *G.B. Patent Specifications*

868535	1059300	1219890
871610	1074356	1277680
911355	1150324	1283869
928487	1184087	1525116
945800	1219415	1545116

13.32.3 *U.S. Patent Specifications*

1841606	2716943	2999389	3339420
1890831	2795957	3026731	3371541
2099593	2857767	3058359	3401567
2183312	2949784	3080763	3747418
2215447	2953925	3129755	3933051
2345071	2973647	3200653	4603483

13.32.4 *French Patent Specification*

1185380

13.32.5 *Russian Patent Specification*

498476

13.33 Whirling Fluid Rotor Gyroscope (Vortex gyro)

13.33.1 *Authors*

D'Amico Jr. W.P. (1984)
 Egli W.H. (1964)
 Osborne J.W. (1877)
 Sarpkaya T. et al (1967)

13.33.2 *G.B. Patent Specifications*

1002151	1201406
1125931	1268700
1125932	
1135517	
1140628	

13.33.3 *U.S. Patent Specifications*

1841606	2995939
1890831	3060751
2856142	3276259
2949784	4270387
2953925	4603483

13.33.4 *French Patent Specification*

1185380

13.34 Torroidal Gyroscope

13.34.1 *Authors*

Jaumann J. (1932)

13.34.2 *G.B. Patent Specification*

1219415

13.34.3 *U.S. Patent Specifications*

1082108	2871703	2966803
2691306	2894396	2971384
2856142	2915902	3371541

13.35 Super-conducting Supercurrent Cryogenic Gyroscopes

13.35.1 Authors

Buchhold T.A. (1963)
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 Cabrera E. (1978)
 Cochlin I. (1963) see p. 66
 Falco C.M. (1978)
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 Juster A. Schizurhe P.K. (1959)
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 Zimmerman et al (1965)

13.35.2 G.P. Patent Specifications

1015153
 1244519

13.35.3 U.S. Patent Specifications

2871703
 3044209
 3216263
 3657927

13.35.4 Russian Patent Specification

540.182

13.36 Vibrator Gyroscope (See also Oscillogro)

13.36.1 Authors

Brozzul L., Orlov V.A. (1969)
 Findlender G.O. and Kozlev M.S. (1963)
 (see p. 78)
 Ryan T.J. (1984)

13.36.2 G.B. Patent Specifications

1078356	1144880
1076357	1245146
1078358	1599082
1093549	2061502
1101258	2164749
1111456	

13.36.3 U.S. Patent Specifications

1801619	3382726
2991659	3463016
3270566	3559492
3318160	4258577
3367194	

13.36.4 German Patent Specification

1548-453

13.36.5 European Patent Specification

EP.0059628

13.37 Vibrating Ring Gyroscopes

Vibrating Bell Gyroscopes

(Acoustic Gyroscopes)

13.37.1 Authors

Bryan G.H. (1889-92)
 Frost H.N. Sethares J.C. Szabo T.L. (1977)*
 Langdon R.M. (1982)
 Leblond H. Bruneau M. Garing Ch (1985)
 Newton G.C. (1965)
 Wood A.B. (1955) (p. 581-583)

13.37.2 G.B. Patent Specifications

1244519	2021266
1288118	2061502
1288449	2113842
1303237	2111209
1540279	2164749

13.37.3 U.S. Patent Specifications

2999389	3367194	3719074	4157041
3164022	3408872	3909710*	4167120*
3182512	3625067	3910373*	4384409*
3232120	3656354	3924475	
3241377	3673872	3926475	
3307409	3678762	4126047*	

13.37.4 European Patent Specification

EP.0175508

13.37.5 International Patent Specification

WC.81/00933

13.38 Electron Gyroscope

13.38.1 Authors

No Entries

13.38.2 G.B. Patent Specification

No Entries

*Surface acoustic wave (SAW) gyroscope

13.38.3 U.S. Patent Specifications

2330849
2871703
2885552
3160018

13.39 Electrically Suspended Gyroscope (ESG)

13.39.1 Authors

Allen D.F.
Elwell D.F. (1973-74)

13.40 Small Low-Angular Moment of inertia gyroscope

13.40.1 Authors

Sapuppo M.S. and Pijoan P.J. (1971)
Simons W.R. (1965)

13.41 Pyrotechnic Roll-reference Gyroscope (Hot Gas Gyro) (Cordite gyroscope)

13.41.1 Authors

Minihan P.N. (1964-65)

13.41.2 G.B. Patent Specifications

842775	1132779
944658	1180546
947103	1330550
978029	2056675
1023963	2117114

13.41.3 U.S. Patent Specifications

1510487	2771778	3285075
2301700	2960877	3393569
2415859	3142184	3908470
2641134	3186241	4271709
2766625	3267748	4280366

13.42 Combined Gyroscope and Accelerometer

13.42.1 Authors

No Entries

13.42.2 G.B. Patent Specifications

1198560
1213868
1312294
1312295

13.42.3 U.S. Patent Specifications

Re. 13755	593174	769493	925709
Re. 14435	596231	769693	934771
185465	596480	859293	936683
204052	637750	885086	944096
236259	640522	888405	960838
302650	653264	889062	991485
385087	661704	896208	1044022
401736	676420	907907	1048817
434172	693374	915858	1071735
458677	701533	919004	1093159
584127	745441	919268	1102653

1112997	2412453	3006197	3502062
1134439	2415056	3009152	3523660
1137234	2425737	3011346	3540289
1147272	2432383	3014376	3540293
1150311	2468137	3018476	3564931
1175959	2472824	3084342	3576134
1183530	2475746	3092432	3604121
1232619	2484819	3109501	3608384
1236204	2497065	3122937	3613458
1259293	2501479	3124007	3664200
1296303	2523959	3142339	3697968
1312085	2525241	3145797	3702078
1330503	2532333	3153353	3723963
1447685	2532334	3166750	3731544
1495911	2534463	3179942	3742770
1501886	2553786	3203644	3756338
1513143	2557590	3205718	3811328
1545812	2568402	3218015	3831454
1548442	2570130	3224513	3871236
1560428	2570653	3232635	3916697
1573028	2577061	3234797	3945769
1586070	2581846	3239118	4020491
1618570	2585579	3242744	4027540
1634950	2635836	3276270	4062126
1645079	2705371	3279263	4068538
1732677	2734383	3283587	4091664
1762409	2809528	3293923	4193308
1800408	2811042	3296870	4241613
1885414	2825789	3313163	4256279
1945874	2871707	3320818	4267736
1947119	2882718	3327539	4295381
1964869	2883863	3338166	4322984
1978425	2914945	3373832	4324378
2051078	2953926	3380310	4361055
2062583	2961877	3393555	4375878
2325048	2964954	3410357	4399714
2389775	2966063	3421117	
2395940	2980895	3426592	
2404172	3005352	3465840	

13.43 Magneto-optical Gyroscope Faraday Effect Gyroscope (Barnett effect)

13.43.1 Authors

Anon (1961-1962)
Barnett S.J. (1935)
Boerdijk A.H. 1956
Braunbek W. 1939
Newton G.C. Jr. et al (1962)
Rothrock R.B. et al (1963)
Schmutzer E. (1978)

13.43.2 G.B. Patent Specification

No Entries

13.43.3 U.S. Patent Specifications

2377175
2566221
2916279
2942479
3225608

13.44 Magnetic Induction Gyroscope

13.44.1 Authors

Anon (1962) ii
Verbrugge F. (1953)

13.44.2 G.B. Patent Specifications

No Entries

13.44.3 U.S. Patent Specifications

No Entries

13.44.4 German Patent Specification

2740-333

13.45 Lindberg Gyroscope

13.45.1 Authors

Capellupo J.P. et al (1960)

13.45.2 G.B. Patent Specification

984269

13.50 Vibrating Gyroscopes

13.50.1 Single Reed Gyroscopes

13.50.1.1 Authors

Anon (1971)
Bryan G.H. (1890)

13.50.1.2 G.B. Patent Specifications

600165	647723	947436	1121750
601051	647895	989101	11249128
610530	670983	994543	1130314
611005	685113	1008999	1139083
611011	685369	1009021	1141727
611021	730783	1049794	1540279
618328	861436	1054082	1599082
639577	932457	1063469	
646794	947310	1102477	

13.50.1.3 U.S. Patent Specification

1728904	2546148	3106847	3992952
2309853	2552650	3238789	4079630
2466018	2594749		4267731
2542018	2974530	Re issue 22409	
2544646	3047766	3538774	

13.50.1.4 Russian Patent Specifications

438327
641343

13.50.2 Tuning Fork Gyroscopes (gyrotron)

13.50.2.1 Authors

Barnaby R.E. et al (1953)
 Börner M. (1966/57)
 Chatterton J.B. (1955)
 Fearnside K. et al (1958)
 Germain J., Wing T. (1961)
 Hunt G.H. Hobbs A.E.W. (1964-65)
 Krasnoshchekova L. Yu. (1969)
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 Maunder L. (1974)
 Meredith F.W. (1949)
 Morrow C.T. (1955)
 Newton G.C. Jr. (1960)
 Pringle J.W.S. (1948) (1957)
 Stratton A. Hunt G.H. (1963)

13.50.2.2 G.B. Patent Specifications

601051	947310	1054082
611005	989101	1102477
618328	1008999	1139083
730783	1009021	1141727
742980	1049794	2061502

13.50.2.3 U.S. Patent Specifications

RE 22409	2683596	3408871
2309853	2753173	3597642
2455939	2838698	3839915
2513340	3127775	4653325
2616681	3241377	4671112

13.50.3 Oscillogyro

13.50.3.1 Authors

Bonfield D.G. (1977)
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 Nuttall J.D. (1982)
 Ormandy D. Maunder L. (1973)
 Whalley R. Holgate M.J. Maunder L. (1967)
 (See Vibra-rotor gyroscope at 13.36)

13.50.3.2 G.B. Patent Specifications

599826
 1023554
 1599082
 3270566

13.50.3.2 U.S. Patent Specifications

3270566
 4258577

13.50.4 Vibratory Rate Gyroscope

13.50.4.1 Authors

No Entries

13.50.4.2 G.B. Patent Specifications

No Entries

13.50.4.3 U.S. Patent Specifications

2455939	2861256
2544646	2974530
2594749	3127775
2753173	3992952
2838698	4079630

13.50.4.4 French Patent Specification

1176197

13.50.5 Piezo Electric Vibrating Gyroscope

13.50.5.1 Authors

Konno M. Sugawara S. Tomikawa Y. (1985)
 Langdon R.M. (1982)
 Westinghouse Electric Corp. (1962)

13.50.5.2 G.B. Patent Specifications

1540279
 2061502
 2111209
 2154739

13.50.5.3 U.S. Patent Specifications

2223537	2683247	3408872	4386535
2513340	2683596	3520195	4489609
2532781	2716893	4079630	4653325
2544646	2724171	4186324	4655081
2546158	2963911	4197478	
2616681	2974530	4264838	
2627400	3182512	4267731	

30.50.5.4 International Patent Specification

WO 81.00933

13.50.5.5 European Patent Specification

EP.0153189

13.50.6 Piezo-electric — magnetostrictive vibrating gyroscope (circumferential flexure vibrating gyroscope)

13.50.6.1 Authors

No Entries

13.50.6.2 G.B. Patent Specifications

No Entries

13.50.6.3 U.S. Patent Specifications

3182512
 3307409
 3408872

13.51 Interferometric Gyroscopes

13.51.1 Authors

Arditty H.J. et al (1981) (1963)
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- Aronowitz F. and Lim W.J., (1979)
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 Vali V. Shorthill R.W. (1976) (1977)
 Vali V. Shorthill R.W. Berg M.F. (1977)
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 Yee H. (1965)
 Yeh P Tracey J. Khoshnevisan M. (1983)
 Youngquist R.C. Shaw H.J. (1983)
 Zernike F. (1947)

13.51.2 G.B. Patents Specifications

1046349	1550579	2068108	2121532
1086898	1589704	2071905	2121954
1116416	1594047	2072335	2126336
1135910	1601309	2073414	2126776
1141727	2004113	2078936	2127211
1143033	2009396	2079525	2127960
1192414	2012101	2087638	2131598
1196940	2017392	2089976	2134248
1203628	2017394	2090597	2136630
1208449	2021851	2093264	2137013
1237663	2028496	2097175	2138624
1255836	2028497	2097176	2138625
1258172	2029631	2097177	2141868
1269104	2032169	2098404	2143366
1285277	2037455	2100055	2143367
1296786	2039036	2100499	2143368
1375959	2044447	2100855	2144261
1388418	2044518	2101802	2145222
1406730	2044594	2105098	2148046
1507847	2045514	2105901	2151806
1509760	2046434	2107511	2156070
1535444	2046508	2108652	2157067
1536077	2049172	2109623	2157823
1536081	2058345	2111297	2160026
1542723	2058346	2112202	2162937
1550578	2067746	2119083	2171246

13.51.3 U.S. Patent Specifications

2841049	3520850	3382758	3395367
3102920	3323411	3382759	3404349
3102953	3332314	3382760	3411849
3277392	3345909	3390606	3412251
3277393	3370253	3392622	3419330
3316501	3373650	3395270	3433568

3462708	3743969	4159178	4429997
3464026	3744908	4160184	4431308
3466121	3752586	4167336	4432646
3467472	3757247	4190364	4433915
3468608	3791738	4198163	4436425
3469922	3807866	4208128	4440498
3473031	3841758	4225239	4445780
3473143	3846025	4243324	4444502
3490278	3851973	4248534	4444503
3494169	3854819	4248535	4445779
3456138	3862803	4255054	4445780
3488606	3867034	4257015	4449824
3503005	3869210	4258336	4470701
3503688	3879130	4259016	4473297
3508831	3890047	4265541	4477188
3512890	3892486	4267478	4483617
3519356	3927946	4271397	4491413
3528029	3930731	4272194	4503543
3530388	3937578	4273444	4504146
3533014	3941481	273445	4514087
3535040	3955152	4274742	4514088
3545866	3973851	4277173	4514832
3563662	3982204	4280766	4521110
3575667	4000947	4281930	4522496
3579846	4006989	4283144	4525843
3581227	4013187	4284329	4526469
3597088	4035081	4287378	4529311
3600095	4039260	4288163	4530997*
3606549	4099876	4290697	4536087
3612690	4107628	4299490	4540284
3617129	4108553	4302107	4545682
3627422	4110045	4309107	4548501
3627425	4113387	4320974	4551011
3642373	4114257	4326803	4561750
3642375	4115004	4329057	4565941
3646468	4119930	4344706	4575855
3646469	4120537	4348113	4580270
3647303	4120588	4349183	4585346
3649931	4123162	4352562	4588296
3691477	4132482	4373814	4595293
3692385	4133612	4386853	4595377
3697181	4135822	4420258	4605307
3714607	4138196	4420259	4606637
3715562	4141651	4422762	
3721497	4152071	4425040	
3741657	4152072	4429573	

13.51.4 European Patent Specifications

EP.0001553	0061360	0092831	0129838
0003086	0063977	0093170	0130766
0007826	0069365	0096213	0132143
0007827	0069366	0096416	0157319
0021419	0069367	0100993	0158557
0026066	0074465	0103080	0160587
0030891	0075013	0103683	0172390
0031274	0075707	0106573	0172391
0039180	0079268	0107373	0185385
0040004	0084055	0109394	
0054821	0088824	0117268	
0059644	0091550	0128230	

* extensive prior art

13.51.5 International Patent Applications

WO82/03456	WO85/03569
WO83/00552	WO86/00130
WO83/01683	WO86/01287
WO83/04305	WO86/01947
WO84/01822	WO86/05039
WO85/03568	

13.52 Nuclear Gyroscopes (Magnetic induction gyroscopes) (Nuclear magnetic resonance N.M.R.)

13.52.1 Authors

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13.52.2 G.B. Patent Specification

2007847

13.52.3 U.S. Patent Specifications

2561489	3103621	4225818	4450407
2561490	3103623	4403190	4509014
2589494	3103624	4406986	4544891
2720625	4104577	4414535	
2841760	4147974	4430616	
3103620	4157495	4446428	

13.53 Bearings and Flexure Hinges

13.53.1 Bearings

13.53.1.1 Authors

Ausman J.S. (1957)
 Bard D.O. (1960)
 Baxter B.H. (1975)
 Beardmore G. (1985)
 Benatti R.J. (1961)
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13.53.1.2 G.B. Patent Specifications

139474	621018	734851	854508
177774	622125	740339	884061
351030	622270	740350	886391
376320	623078	740785	915918
388283	623549	740796	929258
474629	630567	741773	931328
482215	640502	745653	950694
497707	663437	7471	954464
504912	666432	748010	955057
512355	684667	748190	963175
542456	684668	752828	984146
542613	686862	752127	986465
547208	695671	764467	989239
549312	706434	784693	990701
552550	708969	790019	1010343
554620	717349	810279	1011413
592568	719957	810280	1018679
606334	729008	835630	1047833
609476	733673	854507	1051022

1058291	1154254	1310525	1538805
1061282	1156364	1310526	1545774
1066914	1197646	1324504	1562118
1069594	1258741	1354176	1572642
1078289	1264015	1357020	2063471
1103490	1299452	1410219	2064020
1141039	1310523	1432889	2093183
1153923	1310524	1485290	

13.53.1.3 U.S. Patent Specifications

648878	2760376	3233467	3537324
841612	2785573	3237457	3538776
1136666	2793028	3238790	3540294
1226882	2797580	3247725	3543301
1294697	2752684	3257854	3576133
1386029	2760376	3264880	3585866
1452483	2785573	3269394	3606793
1600871	2793028	3315533	3662609
1729734	2797580	3319473	3677097
1843868	2871706	3326053	3684678
1945592	2915902	3334949*	3703831
1978425	2919583	3336810	3708231
1986807	2919585	3336811	3722295
2048834	2930322	3339420	3722296
2091888	2940318	3339421	3722297
2133809	2944425	3354727	3802275
2199024	2959059	3356425	3803924
2244603	2960872	3358514	3877317
2276634	2969680	3360996	3878730
2314343	2990716	3362233	3886803
2330729	2992562	3362234	3908470
2334002	2995631	3365958	3982441
2410622	3002392	3451289	3985034
2417066	3046794	3452608	4000660
2417081	3073584	3482454	4043614
2517612	3077785	3487701	4100813
2519159	3080762	3489016	4114960
2577942	3131538	3515006	4157465
2606447	3132315	3512419	4380355
2620668	3142189	3526142	4466299
2649808	3194051	3522737	4570507
2735731	3200652	3530728	
2752684	3225606	3534616	

13.53.1.4 German Patent Specifications

1497256
2337844
2649182
2734058

13.53.1.5 French Patent Specification

2329890

13.53.2 Flexure Hinges

13.53.2.1 Authors

Beardmore G. (1985)
Eastman F.S. (1937)
Geary M.E. (1977)
Haberland R. (1977 1973)
Wittrick W.H. (1948)

*Mathematical dissertation

13.53.2.3 G.B. Patent Specifications

959258	1152587	1315432	1545774
1058780	1230676	1348618	1582857
1031839	1245146	1364757	2036311
1103490	1274599	1378946	2042723
1142846	1284195	1514227	2046905
1142847	1289000	1514228	2063471
1148582	1304571	1538855	2067654
1150532	1304751	1541330	2163849

13.53.2.4 U.S. Patent Specifications

30290	3353412	3618403	4147063
376187	3354726	3668502	4197765
1393845	3365960	3677097	4202089
1891619	3373617	3678704	4207668
1913886	3413858	3700289	4217787
2238380	3427828	3700290	4232917
2517612	3452608	3700291	4261211
2606447	3453894	3709045	4266431
2735731	3483760	3722206	4269072
2793028	3498144	3748912	4270392
2797580	3512419	3754475	4270393
2893247	3515006	3762226	4285248
2909064	3515034	3832906	4286370
2960362	3527062	3856366	4297853
2995938	3529477	3943778*	4297904
3002392	3534616	3974791	4326428
3063670	3538776	3987555	4332365
3074682	3540293	4000659	4336967
3077785	3543301	4002078	4357837
3081552	3544175	4033371	4380108
3119607	3550395	4062600	4386535
3165945	3557629	4077236	4395922
3176523	3575475	4082005	4397185
3211011	3576133	4100813	4454777
3264880	3584513	4114402	4464942
3290949	3585866	4122689	4499778
3301073	3610051	4126046	4592242
3307411	3613457	4143451	4596158

13.53.2.5 German Patent Specifications

2525330
2544580
2653427
2714085
2751034
2818106

13.53.2.6 Russian Patent Specifications

507775
657246

13.53.2.7 European Patent Specifications

EP.0009347

13.53.2.8 International Patent Specification

W079/01161

13.53.2.9 Belgian Patent Specification

628098

*Contains extensive list of prior art.

13.54 Mountings Cardan Suspensions (Gimbals) Cagings (Suspensions Generally)

13.54.1 Authors

Bogatskaya I.G. et al (1971)
 Bogoyavlenskii A.A. (1974)
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13.54.2 G.B. Patent Specifications

20135 of 1912	810280	942826	1545774
101367	811009	954464	1564105
422862	840370	984416	2046905
564783	840395	1058780	2088553
568614	858005	1378946	2106245
640631	895375	1486189	2107056
790175	900138	1496405	2133302
794236	901756	1520139	2135775
819279	915918	1522138	

Cagings

419816	635126	785126	952219
571664	684668	796050	976669
573710	701385	857552	1020200
578604	716779	857553	1068371
579874	729946	866409	1078289
582540	761521	878891	1092344
583907	765313	878894	1104951
591722	776845	885085	1115316
622270	776610	886728	1115832
631329	777973	921740	1244549

1378946
1599082
1349777
1496405

Gimbal or casing follow-up arrangements -- damping oscillation

9737-1911	530222	784576	1032473
2735-1914	530549	789556	1037106
10095-1914	535966	797929	1040004
14486-1914	549041	798989	1054238
22379-1914	549944	798107	1056528
565-1915	553344	807292	1056624
3318-1915	553730	815556	1068426
16098-1915	587631	821748	1069456
107572	587718	825927	1085498
110369	587897	825920	1086539
125096	601447	840395	1092997
125660	604208	845808	1095131
125791	612571	856374	1095017
127055	621836	872777	1097682
129724	625869	874563	1101956
139056	626634	875754	1108391
145465	627291	878029	1144880
146374	635052	879683	1152447
153588	638714	885303	1152566
164396	640562	885063	1152587
177153	643789	886291	1157966
179918	649704	889835	1159770
188390	654041	895064	1171719
217405	657669	895375	1172441
229869	657671	898595	1173647
246741	670983	900138	1175863
269042	677306	911913	1189631
292051	680944	914128	1196170
316380	682908	918197	1207660
331627	684567	918524	1239176
340327	684668	923406	1254385
346466	687135	924214	1264015
353296	698031	932173	1264285
371235	698032	933251	1284206
373832	707518	935905	1315119
376320	712993	944325	1330550
379134	713511	947322	1358258
382782	716871	960437	1388082
422116	719957	964648	1396163
425890	722497	972762	1410895
457483	741960	973122	1425092
479279	751142	978029	1483951
482215	753127	983658	1525116
488601	753449	987921	1580092
497584	760251	1008232	2905411
501545	765675	1013725	
522684	767069	1021801	
523947	772345	1030796	

Mountings and suspensions or rotor or rotor casing - liquid buoyancy

10440-1911	148989	367692	762301
26160-1913	150457	448051	762346
108677	167503	682908	762750
132815	187985	713511	772432
132839	193397	722492	772433
146372	296670	740349	791556
147062	290790	740350	798089
148274	309924	740796	798107
148965	311972	753127	812875
148967	352335	753449	815556

820480	889864	992535	1129294
825917	895375	1013275	1129595
825913	900138	1015681	1132851
826418	911913	1025325	1141384
826419	924744	1026570	1150324
826420	926959	1037106	1167286
840395	928487	1037756	1183034
845808	931398	1047833	1186642
847378	932173	1048615	1203841
852562	933251	1054238	1207660
854506	941317	1056557	1244519
854507	941533	1064219	1280652
854508	957196	1069080	1349229
856374	958988	1069566	1357020
867867	964648	1072365	1396163
367868	971613	1074356	1410580
878029	972762	1081795	1410895
878939	973122	1083157	1456883
879683	976517	1084456	1505519
885308	977873	1095817	154204/5
886063	983658	1102813	1555286
886391	985324	1117848	1564686
889385	990701	1121899	1576631

Mountings and suspensions or rotor or rotor casing -resilient means

565-1915	686862	1078357	1283118
117827	687135	1078358	1284195
125628	713511	1084456	1289000
125660	745653	1093549	1299822
127007	772849	1093550	1304571
127287	784576	1101258	1304751
153588	810279	1101259	1310525
167503	810280	1103490	1312294
307619	812875	1111456	1312295
333651	840370	1132948	1315432
497033	857754	1142846	1340462
497584	879683	1142848	1348618
497707	886391	1148582	1364757
518846	889864	1150532	1396163
549041	900138	1152585	1446112
553094	911490	1152586	1481839
587719	933251	1152587	1491953
591182	959258	1155545	1511430
592645	964446	1160039	1520139
600661	964447	1175863	1522138
606334	964648	1189631	1538069
606335	972762	1195560	1538805
616374	980529	1227130	1541330
617108	1026570	1239176	1545774
640631	1054238	1245146	1553488
666432	1058780	1258439	1589789
675048	1068371	1269054	1589790
677306	1078289	1274599	2005411
684667	1078356	1280652	2007840

Mountings and suspensions or rotor or rotor casing -three ring systems

11827-1915	734851	924744	1034314
320355	762301	935976	1040392
439630	762346	942826	1051905
598470	821416	950694	1055338
608851	821417	980529	1071371
617055	863456	985324	1072365
626634	863457	988089	1095131
626635	863458	997469	1101934
635192	921740	1009169	1173564
645408	924093	1032473	1178703

1183034	1396163	1410895
1213868	1398905	1484793
1263424	1398906	1521638
1330550	1405275	

Mountings and suspensions or rotor or rotor casing -unclassified

9737-1911	544094	763750	963175
15669-1911	545694	772432	964648
22870-1911	549312	772433	971613
26068-1913	551823	772849	973629
14032-1915	553094	777973	978029
101367	553730	784473	985324
104191	578958	784576	986485
123438	580248	784693	988898
125628	587719	790019	989939
127007	591882	791556	990701
127055	600661	794236	992535
127287	603430	797929	1008282
135500	630711	798089	1009169
139474	606334	798107	1010343
140142	606335	802776	1011413
141139	607349	804306	1013275
148966	607353	804372	1015 81
149727	612723	807292	1016260
150452	618540	810279	1017590
160316	625288	810280	1018679
166868	625415	820480	1020200
175292	625869	825917	1021650
194714	626634	832480	1023903
210062	626635	836816	1025325
244843	630657	838383	1032473
306603	635192	840370	1047833
309150	640562	840395	1048615
309910	640631	840427	1051905
341519	649704	845808	1054238
344239	666432	846879	1056557
346466	677306	852562	1058291
351030	682908	854507	1059300
351672	684667	854508	1061282
365188	684668	858005	1066914
375278	687135	866473	1068371
378148	698032	871147	1068426
383164	706434	875754	1069594
387366	707446	878939	1075277
388283	707518	884061	1078771
401039	708873	886063	1081795
410839	713511	889864	1083157
427422	719957	895375	1084280
428533	723377	898595	1085498
460244	726627	900138	1089070
463332	726849	901220	1095519
463396	726890	902264	1095817
464263	729672	911490	1096831
466864	731737	911913	1100524
466865	732975	927112	1101258
474629	733058	931398	1101259
479279	733678	932173	1101956
483370	734851	937444	1102813
501856	740349	938705	1104525
504753	740350	941533	1111374
504913	740796	944828	1111676
505900	741773	947322	1117848
505901	748010	950694	1126611
509178	751142	955057	1132779
512355	752828	958988	1134273
522384	753127	959258	1141039
524017	753449	960437	1141385

1144880	1205065	1310525	1414297
1152447	1207336	1314304	1417585
1153921	1213407	1315119	1425092
1154254	1224992	1324458	1446112
1156364	1227130	1324504	1456883
1159770	1239176	1325152	1488951
1160295	1244519	1332911	1497065
1160528	1259753	1333529	1511430
1167286	1264015	1343690	1535174
1172441	1264285	1351873	1543630
1175863	1270567	1356667	1545116
1178703	1271728	1357020	1562118
1181704	1273522	1364757	1565135
1183034	1274599	1368037	1570304
1184087	1275880	1383348	1579920
1197253	1280776	1388082	2002116A
1197646	1284206	1400488	
1198560	1284492	1410219	
1202456	1299822	1410580	

Mechanical caging devices

11459-1912	521913	765313	996283
18859-1913	524204	772005	1008282
29010-1913	536495	776610	1017590
17895-1915	537777	776845	1023903
100393	543455	777973	1039695
102044	543482	785126	1068371
146372	562688	791556	1078771
160316	564840	796850	1092344
213791	569160	807292	1104525
218415	571664	808829	1111676
284505	573710	832480	1118509
366058	577209	842715	1132779
366764	578604	843446	1152447
379139	579816	857552	1162616
393354	579874	857553	1175863
411921	582540	866400	1180546
413715	622185	872777	1188067
416813	623943	874101	1196401
418377	625415	878891	1197646
419816	631329	878894	1213407
421079	635126	885085	1224992
425111	635192	886063	1231069
427422	648492	886728	1244549
434364	655536	898804	1259817
437861	670983	898805	1324504
451844	692986	925441	1325152
471217	701385	928487	1436941
474280	716779	932173	1456883
484775	724428	941533	1545116
491476	726627	944658	1554204
495431	729518	947322	1554205
496521	729672	953586	1555286
504876	729946	976669	2011671
521160	761521	990701	

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1226882	2766625	2944425	2997885
1501886	2782642	2959059	3002392
1797913	2822695	2967430	3046795
2158180	2836981	2970480	313568
2183312	2846885	2971383	3186239
2209735	2865205	2973649	3216262
2582788	2909064	2984113	3246527
2584472	2924978	2990718	3248952
2740299	2939322	2992562	3252337

3321980	3505881	3926060	4267737
3365958	3677098	3941001	4270393
3396586	3678764	4021716	4297904
3446080	3709045	4122689	4355540
3452608	3837229	4193308	4483207
3457793	3898884	4217789	4570507

Gyroscopes with caging or parking means

1075770	2393124	2741922	3020769
1186856	2406698	2786356	3039316
1404329	2419382	2787908	3046796
1451928	2422267	2790119	3110187
1704489	2423270	2795142	3111038
1717837	2441157	2799169	3114269
1788807	2441307	2808726	3115784
1800408	2457150	2808727	3172213
1851536	2459496	2815668	3174346
1896805	2459879	2826080	3229532
1918082	2468016	2841015	3232121
1955746	2491813	2841987	3250135
1959309	2507451	2842967	3272019
1982637	2519454	2846886	3283592
1988463	2523270	2867122	3292269
1996895	2524553	2872821	3322338
2001038	2527055	2874576	3430499
2005379	2555981	2874577	3455030
2018735	2556253	2879672	3457793
2091964	2564772	2884787	3473391
2105148	2567053	2887884	3474688
2133489	2580748	2889710	3477297
2139670	2585693	2891407	3508447
2162698	2591741	2898338	3522993
2178623	2625045	2907212	3526143
2182534	2636389	2919584	3528300
2190698	2641133	2919586	3534617
2202955	2645129	2921472	3610052
2203708	2645942	2935942	3839916
2207717	2651205	2937531	3926060
2247142	2654254	2940319	3992955
2278913	2674891	2945648	4009848
2280116	2685206	2951375	4020701
2283720	2694314	2951378	4027540
2295158	2697354	2960874	4036453
2297274	2698542	2960875	4069990
2348603	2716344	2960877	4147066
2348731	2722124	2962901	4149418
2350769	2726550	2964951	4155521
2366721	2727393	2982138	4236414
2368221	2729978	2990719	4266431
2369845	2732719	2996921	4322984
2380538	2734279	2996922	4345485
2383663	2737052	3019662	4355540

Gyroscopes with caging or parking means — rotor spin and cage release type

18168	983467	2415899	2924104
562235	1030134	2521379	2951378
607440	1077344	2715709	2960877
621364	1145025	2732721	2982140
661535	1153678	2769343	2986945
741683	1173435	2841987	2996922
768291	1185210	2846889	3010327
814969	1192468	2872822	3012439
818987	1291031	2887884	3017778
894838	1296137	2895338	3082630
925710	1296331	2911832	3086490
954634	1421854	2921472	3102430

3115784	5261214	3434354	3913870
3129594	3263508	3434355	3933096
3137966	3267748	3438269	3982441
3142184	3270568	3446082	3985034
3162053	3270985	3449960	3992955
3180223	3273406	3451289	4024769
3186241	3287982	3554466	4271709
3187588	3290787	3570282	4275604
3192777	3299717	3604277	4305304
3205719	3299718	3677098	4322984
3232121	3323379	3807239	4346614
3247726	3393569	3898889	

Gyroscopes with caging or parking means and resetting means

1694192	2200976	2360935	2924104
1946657	2207850	2379869	3323379
1974220	2207875	2406342	3898889
1996896	2214538	2483826	3926060
2061894	2217255	2491204	
2111388	2273309	2572827	
2175143	2298626	2807169	

Gyroscopes with gimbal lock preventing means

2158048	2493015	2802364	3188870
2195351	2512607	2816448	3203261
2366543	2561367	2846889	3383926
2367667	2584876	2909929	3470751
2368644	2588755	2934960	3470752
2390532	2595951	2978912	3509777
2409875	2649809	2983150	3941001
2439358	2655046	3004437	4052654
2450875	2677194	3029464	
2452473	2747431	3069911	
2469782	2752789	3675729	

13.54.4 International Patent Specification

W0 7901161

13.55 Rotor Construction

13.55.1 Authors

Beams J.W. 1947
Conference on Scientific Aspects of High Speed Rotation (1975)
Henriot E.J.C. Huguenard E.A. (1925) (1975)
Laithwaite E.R. v (1977)
Muller H.H. (1976)
Ovcharova D.K. Golosholov E.G. (1971)
Red W.E. (1974)
Sann R.I. (1970)
Yarber G.W. et al (1966)
Zholdak S.A.

13.55.2 G.B. Patent Specifications

21271 of 1910	513290	591598	838816
5314 of 1915	529751	611045	842775
102044	531870	623943	868535
123836	535160	729008	870604
141139	545397	733678	876433
146302	546152	740796	886305
405513	554199	764467	932173
464315	554594	764644	1017086
474202	569804	817570	1018679
504963	574110	838383	1039695

1069594	1265832	1386897	2070244
1078771	1284195	1417585	2049932
1126611	1337054	1522138	2135775
1152586	1349777	1565135	2166867
1152587	1352981	1562118	
1156264	1354176	2007840	
1264015	1362149	2025066	

Rotor Construction

8379-1913	751018	1018509	1258439
11827-1915	764644	1018679	1264015
101367	784576	1023554	1274599
123438	784693	1024764	1277680
128345	790019	1039695	1283869
134234	802776	1056819	1284195
161133	825317	1058780	1284206
162604	832480	1059330	1304571
251389	836816	1061769	1308205
378148	842775	1066914	1310525
383164	868535	1069594	1312294
418377	870604	1073446	1312295
427422	871147	1074356	1314304
460244	874563	1078356	1315119
463332	876433	1078357	1315432
474020	884061	1078358	1318872
474629	885303	1081795	1324458
479279	886391	1083157	1324504
483370	889864	1086539	1325152
490724	890264	1093549	1330550
504963	898595	1093550	1337054
509178	898804	1095515	1340452
513290	901220	1101258	1343690
530549	904570	1101259	1349229
542618	911355	1102813	1349322
542963	911490	1104525	1352981
546504	911913	1111374	1362149
547022	917452	1111456	1364657
547208	926100	1121117	1368037
554594	928487	1141039	1386897
554620	933251	1142846	1388082
569804	937444	1142848	1410219
574848	944828	1144880	1410580
578958	945800	1146833	1417585
592568	947103	1148582	1425092
599826	950964	1150324	1446112
603038	960437	1152585	1477603
603427	963175	1155545	1488951
609476	964446	1156364	1491953
611045	964447	1159770	1497065
622185	964648	1160039	1506180
623943	971613	1160528	1511040
655536	971984	1163017	1511430
682528	973122	1168261	1522138
691646	973629	1179601	1525116
695671	984269	1180546	1538069
698031	986485	1184087	1538805
708969	987921	1188067	1541330
722492	988898	1196401	1545116
732975	990701	1197646	1553488
733058	992535	1198560	1562118
733678	996283	1202456	1565135
740349	1008765	1213407	1580092
740350	1010615	1219415	1589789
740785	1016260	1219890	1589790
740796	1017086	1231069	1605164
748198	1017590	1244519	

Gyroscope apparatus constructional features or details unclassified

5843-1911	671411	772432	1061256
19555-1912	680944	814914	1086299
20135-1912	692986	817570	1089070
12959-1914	623078	858005	1095519
101225	623080	865642	1104951
129724	675048	870604	1115832
148309	681926	886728	1126611
166907	682528	898595	1156364
179918	707660	898804	1160528
188390	708875	911913	1172441
341519	709997	926100	1180546
368310	716871	933251	1202456
428533	717322	938705	1254385
441439	722492	944828	1264285
444715	723377	945387	1269817
461257	724428	947322	1278794
504963	726890	953585	1280652
545152	729241	959258	1330550
568614	729672	986485	1349322
581891	731737	987921	1349777
591598	740349	1011413	1425092
609476	740350	1017590	1428908
622185	741960	1024625	1469123
622270	753258	1029012	1486189
636545	764467	1054238	1497665
640562	765675	1056819	2007840

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1426336	3129593	3822602	4305304
1426339	3248952	3880606	4426889
2641132	3274666	3988347	4315389
2716893	3290948	3974701	4343203*
2771778	3505228	4281555	4464943
2919585	3529477	4283959	4521109
3043147	3719092	4299127	

Rotors

3229	128460	353349	640096
3299	151310	379807	660679
12441	203623	382008	670385
17222	215805	402564	670388
22003	225068	415264	671160
23299	235876	422606	672267
24600	238838	426002	691491
38025	245247	429804	694552
40011	246657	442570	697175
44466	248978	449572	703724
54220	252457	477324	705702
57348	271132	492654	717974
58925	284369	521768	746323
59032	286702	548131	747968
60126	289992	554138	748380
60221	299013	554577	753735
65420	300443	565378	762851
68530	302700	575741	773097
79403	307975	577065	785127
94091	318094	583756	789205
99659	331920	590252	791033
105870	339476	590554	796893
118022	341736	600446	798682
122502	342586	611719	798985
128408	349547	636372	830273

*See German 2527464

803556	960277	1185192	1653856
804806	961740	1186856	1663814
807048	961877	1192381	1677030
815309	961878	1196537	1683954
837874	961879	1199165	1687513
843823	962158	1204839	1701274
843917	965811	1220767	1703991
845615	976953	1227335	1706678
848140	978893	1227593	1722800
855812	986978	1235153	1729659
858711	996148	1239046	1734267
860336	997851	1242285	1765754
860505	998728	1248807	1767916
861022	998734	1254694	1789579
861658	999758	1255747	1798108
861687	1004607	1257371	1808568
853120	1008194	1264642	1808572
864013	1008316	1265747	1810538
864126	1008502	1265899	1811916
865958	1011577	1279529	1813957
867207	1012407	1281306	1817054
874095	1020226	1281725	1822826
882037	1020913	1285418	1843162
887022	1021116	1295486	1844710
887825	1022881	1298645	1855570
890225	1025589	1310558	1874712
891794	1025684	1315041	1874713
892337	1030993	1318302	1881234
892338	1038239	1319040	1881393
893907	1042853	1329348	1888027
895041	1044022	1332966	1890550
895518	1046034	1333135	1898290
895585	1054339	1335754	1902505
896960	1055643	1337417	1908625
897074	1056872	1346755	1915150
897432	1062370	1356024	1919961
898132	1063432	1360216	1923611
902174	1076219	1365473	1924385
904314	1076614	1381354	1933436
905253	1087936	1384121	1935980
906334	1093246	1391293	1936737
913145	1093982	1395470	1938152
916068	1097460	1415442	1944776
917032	1097904	1418330	1946725
921195	1101410	1424987	1960039
925564	1102116	1426336	1969755
928544	1104830	1426339	1981167
930562	1108531	1436442	1988762
930706	1108938	1447390	1995010
931006	1110733	1451818	2002561
932534	1110840	1481390	2005941
933672	1127251	1494109	2029318
933692	1129280	1505080	2039844
933895	1132478	1515784	2047420
933913	1134110	1532962	2055179
933945	1139893	1541411	2061261
934886	1146533	1543849	2061827
935551	1150311	1554755	2064452
935552	1153268	1567574	2064669
935553	1154005	1578247	2070485
939645	1154007	1588795	2074822
945250	1161178	1592021	2076438
946115	1161812	1595717	2085230
951995	1164250	1610504	2092159
955413	1165919	1618554	2092185
957024	1169199	1627964	2105742
957243	1172264	1645268	2118590
958188	1177608	1650201	2131469
958452	1180815	1651944	2136312

2164971	2704416	3312125	3970917
2174168	2716356	3338048	3971146
2183670	2719438	3360444	3977273
2196064	2721733	3363479	3982447
2205594	2723572	3364787	3983738
2210372	2730911	3365351	3985043
2217351	2734487	3368424	3988947
2225219	2738450	3382667	3990633
2236756	2745338	3385130	4000665
2241689	2747386	3412603	4002043
2244603	2757050	3424026	4011120
2251390	2764721	3435704	4019396
2261019	2773400	3439554	4020714
2263220	2794605	3455104	4021086
2277923	2804925	3476201	4023437
2282071	2815632	3479905	4027484
2284428	2815681	3485037	4027485
2286641	2826094	3490748	4028962
2290588	2835141	3493066	4030371
2290589	2858855	3496799	4031240
2292672	2866359	3537332	4031420
2301943	2879674	3574325	4036080
2308028	2895690	3577777	4041801
2313269	2913190	3602066	4050557
2331565	2914962	3602067	4052913
2341695	2933940	3602602	4058024
2341834	2935899	3608395	4063009
2350218	2941800	3627056	4069669
2351485	2942488	3635320	4080845
2384110	2943503	3659767	4084482
2392858	2957365	3662619	4084924
2395447	2962905	3665788	4085927
2404515	2982150	3672241	4086390
2420269	2995938	3675506	4086506
2428973	3014541	3683216	4088041
2432383	3022433	3691413	4094142
2438206	3023636	3698262	4097194
2441432	3039421	3724288	4098142
2443770	3056301	3733916	4102220
2454620	3061849	3737694	4102221
2466153	3067847	3741034	4110982
2470435	3074297	3754696	4111067
2470561	3077785	3756751	4112785
2474370	3078726	3782212	4116006
2480550	3082675	3788167	4116088
2482644	3111290	3790831	4123949
2500366	3128639	3805638	4124327
2512847	3129559	3818586	4128020
2516207	3142901	3834242	4131171
2525946	3168838	3838301	4132130
2535842	3176565	3841173	4138286
2536226	3208303	3859868	4150582
2539730	3216655	3862677	4159427
2540854	3234644	3866725	4176563
2549604	3237480	3867814	4179951
2576250	3242765	3871237	4182138
2580944	3244016	3882950	4183259
2600552	3246537	3884093	4186245
2603103	3248967	3885814	4186623
2621140	3267768	3885810	4187728
2627414	3280653	3918830	4190626
2639203	3282498	3937103	4198878
2647408	3292834	3949556	4207778
2656733	3296856	3955428	4208921
2659244	3296894	3960034	4220233
2685804	3299735	3961445	4223240
2697965	3303718	3964341	4231268
2699295	3303751	3965759	4241620
	3307423	3970409	4241654

4244240	4283966	4329389	4388977
4254668	4285251	4331042	4406121
4257229	4285625	4332163	4407399
4262552	4286475	4335627	4408500
4262840	4294343	4341001	4410074
4266442	4305489	4342371	4411171
4267805	4310079	4343203	4413860
4270410	4317435	4346624	4415360
4281560	4324995	4346773	4420070
4282947	4325472	4359912	4422263
4282948	4326153	4370899	
4283959	4326430	4381038	

13.55.4 German Patent Specifications

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13.55.5 Russian Patent Specifications

484393
437906

13.55.6 European Patent Specification

EP 015707

13.55.7 International Patent Specification

WO 85/03055

13.56 Rotor Driving Speed

13.56.1 Authors

Henriot E.I.C. and Huguenard E.A. ii (1925)
Karelir V.A. (1973)
Magnus K. iv (1940)
Martynenko Yu. G. (1973)
Pickles E.G. Beams J.W. (1935)
Roitenberg L. Ya. (1966)
T'shou Li. Langman R.W. (1982)
Wippell A.P.R. Maundes L. (1963)

13.56.2 G.B. Patent Specifications

581737	944658	2025066
717322	1290731	2028538
807065	130105	2059635
836817	1325152	2137445
839770	1508376	
872777	2012998	

Rotor driving and speed control arrangements: — air (or other fluid) driving means

8302-1911	196296	361672	411921
6163-1913	213791	361836	413715
17872-1913	218353	364625	416813
2570-1914	220726	365190	419816
5514-1915	231229	378148	422116
101367	242093	382782	425890
123836	246741	387366	425957
125628	261117	391111	431634
129307	274980	392163	434364
140142	281691	393354	440980
147271	306603	393695	453238
152008	340327	394412	457483
164396	351030	405513	460244

462826	544094	599607	984269
463332	545397	601964	990701
464263	545694	606334	1014325
466865	547208	606595	1018679
471217	549105	607353	1023903
471537	549572	611004	1024764
474629	551245	617055	105914
475321	552550	623078	1078771
476034	553094	645408	1081795
477012	553730	684667	1083157
479243	554164	684668	1092997
479279	554199	729008	1104525
495431	562886	733678	1132779
497655	564783	764467	1180546
501856	565246	790019	1197646
504876	565351	796850	1213407
504913	565802	802776	1231069
508213	568692	832480	1270567
509178	569804	842775	1271728
510789	572201	866400	1277680
511742	574043	866916	1283869
512355	574110	871147	1284206
521160	574848	872777	1325152
523947	575281	874101	1330550
525876	579816	875754	1346558
526360	579822	884061	1349229
528569	579909	911490	1383348
529751	579991	925441	1386897
530549	581737	937444	1414297
530582	581891	944658	1497065
535270	591182	947103	1562118
538346	591405	964446	
538943	591768	964447	
542963	599248	978029	

Rotor driving and speed — control arrangements — braking

134234	551245	886063
191410	556264	939622
457483	579822	1580092
487589	729516	

Rotor driving and speed — control arrangements — electric driving means

26906-1911	251389	490724	581737
8952-1912	259199	497584	582301
11459-1912	273952	504963	591598
17895-1915	290670	517587	593753
101225	294691	518817	601556
102044	309924	518846	601964
110157	315966	529751	603038
119511	316380	531870	609476
128345	361836	537778	619960
129724	364625	539011	622185
130143	378148	545694	623356
134234	383164	546152	623634
140482	389819	546501	623943
143969	405034	553730	641360
146302	428533	554594	645408
150452	434364	554595	678768
153589	441439	554596	682528
163315	448763	554620	682908
164285	453744	556244	686862
177153	460244	558276	698031
179918	464315	561018	708873
191407	471217	568614	719957
206541	475097	572213	722492
217405	476013	575281	724428
247265	487589	578958	726849

726890	879894	1055334	1189631
729008	878939	1056357	1197646
729672	879683	1053291	1198560
732975	884001	1058780	1201828
733058	883303	1061282	1202456
734148	885246	1064219	1219415
740349	885947	1066914	1219890
740350	886063	1069594	1225074
740785	886391	1072365	1231069
740796	889664	1078356	1239176
741960	892969	1078357	1254385
748010	898595	1073358	1258439
748198	898804	1084280	1259753
751018	900138	1084450	1270567
752828	901220	1085498	1274599
753258	911355	1089070	1284195
756504	911490	1093549	1284492
761521	911913	1093550	1292287
762301	917452	1095519	1299822
762346	921562	1096831	1304571
763750	926959	1101253	1308285
764467	928487	1101259	1310325
764644	931398	1101956	1312294
767069	932173	1102813	1312295
772432	933251	1103490	1315119
772433	939622	1109615	1330550
778533	941533	1111374	1331150
784576	944828	1111156	1337054
791556	945800	1111676	1340462
798107	947322	1117848	1346558
798485	950694	1134273	1349229
802776	953585	1141384	1352981
804006	957195	1141385	1356667
807292	958988	1142977	1357020
811009	960437	1144880	1364757
812875	963175	1145795	1410580
815556	964648	1146833	1411201
817570	971613	1149068	1425092
820480	971984	1150324	1446112
825917	973122	1152447	1456883
826418	973629	1152585	1477605
826419	986485	1152586	1488951
826420	988898	1152587	1505519
838383	989939	1155545	1511430
839770	990933	1156364	1520139
840395	996283	1159770	1530869
840427	1010343	1160039	1545774
845808	1010615	1160295	1553488
847278	1016260	1160528	1554204
854506	1021650	1163017	1554205
857552	1026570	1167286	1555286
857553	1029012	1168261	1565135
868535	1037756	1175863	1589789
870304	1042940	1176228	1589790
874563	1048615	1176735	2002116
876433	1051917	1179601	2005411
878029	1054238	1184087	

Rotor driving and speed control arrangements — unclassified

332-1912	581737	686862	740796
3318-1915	629305	695671	741960
100393	637993	698031	748198
131992	641360	724428	751018
155638	656889	729008	752828
301278	675048	732975	756054
410839	682528	733058	761521
418377	682908	733678	764467

764644	836817	1056528	1196401
772432	838383	1056819	1244519
772433	898804	1058780	1324458
778533	938705	1092344	1333529
790019	987921	1142977	1349229
791556	990933	1145795	1349322
796859	1008765	1149068	1491953
798107	1016260	1159770	1508302
798485	1017086	1160528	1564686
814919	1024764	1174464	1570304
817570	1039695	1188067	1605164

13.56.1 U.S. Patent Specifications

1301014	4266432
3276272	4267735
3931742	4269073
4240301	4274291
4258579	4460853

Multiple gyroscopes with rotor drive.

238631	1603352	2698867	3055223
769493	1610853	2613538	3069912
794654	1621815	2630015	3136164
807195	1639233	2641134	3176524
844837	1645079	2653481	3188870
865277	1655800	2685207	3192778
865278	1692412	2725750	3196694
940329	1713942	2835131	3204467
960838	1781746	2857767	3212342
1044022	1856436	2864017	3224513
1086242	1946657	2894396	3263507
1186856	1999897	2912865	3276267
1226385	2104226	2928282	3282118
1253574	2109282	2941406	3283593
1253666	2176804	2948157	3327540
1273799	2256475	2949785	3476129
1309489	2303799	2953926	4258579
1312085	2380941	2972892	4274291
1335055	2420674	2999391	4320669
1558514	2432430	3006581	4351194
1560428	2448905	3029647	4354395
1573028	2548974	3035477	4409856

Gyroscope with rotor drive

24430	1048817	1318980	1597752
99644	1067808	1319323	1605289
442461	1075770	1359333	1610930
462512	1096253	1382372	1617309
505575	1112997	1385423	1629577
557300	1137234	1407491	1630394
591768	1143975	1410931	1640549
596231	1145025	1416038	1651845
617665	1146183	1429577	1653660
654882	1148154	1431140	1704575
698286	1164185	1440822	1718539
705702	1175827	1464576	1764714
712709	1192468	1469094	1778734
791983	1192532	1486261	1791755
884975	1223914	1495769	1794749
942052	1236504	1499602	1802108
995819	1279471	1510487	1810646
1021116	1286595	1511240	1825293
1025747	1289170	1554732	1857736
1033994	1298664	1558720	1861692
1033995	1309636	1558721	1964801
	1311509	1558722	1870085

1890831	2315019	2731836	3044309
1894038	2325530	2737815	3055635
1924816	2328744	2741922	3060751
1932412	2334249	2743576	3071011
1940622	2335106	2778227	3074283
1954993	2338098	2780940	3077672
195720	2344112	2786357	3078728
19742	2345915	2801543	3080763
1975740	2353150	2809527	3086400
1978425	2357381	2815584	3094878
1982635	2358927	2819053	3097535
1982636	2364810	2822694	3102430
1982637	2366707	2829523	3105657
1984859	2367667	2839934	3107540
1986807	2378853	2841017	3115784
1987483	2380578	2850905	3129301
1987763	2382135	2852943	3133213
1989826	2382967	2856142	3137966
2005112	2384838	2857122	3140853
2009263	2386686	2857534	3142182
2011453	2393473	2859625	3142183
2018735	2395447	2859626	3142184
2025194	2399539	2871705	3146433
2031286	2412173	2871706	3157053
2036288	2412481	2872822	3160018
2044183	2413285	2874576	3162053
2046735	2416300	2876643	3162951
2047186	2422120	2880616	3165972
2053185	2423269	2891407	3174346
2054055	2423270	2898552	3176324
2061261	2426554	2898765	3180223
2075797	2427549	2899945	3183725
2078734	2434488	2902863	3186241
2080490	2438621	2911852	3187587
2086896	2439358	2918869	3187588
2086897	2445388	2919585	3192777
2087961	2466302	2921472	3192778
2099593	2474072	2928960	3200748
2102538	2504166	2930240	3203260
2106194	2524553	2936711	3209602
2124817	2524756	2937804	3214982
2129818	2534824	2942479	3225609
2133809	2539363	2947178	3226984
2135229	2547968	2948156	3226985
2137540	2567948	2947784	3232121
2138531	2588607	2953925	3233467
2142018	2589873	2960873	3238432
2157360	2589874	2960876	3238792
2161241	2595268	2960877	3240076
2163528	2605641	2963912	3242743
2176804	2607231	2964953	3241955
2180043	2608869	2969682	3252340
2181250	2609693	2971384	3254538
2193531	2615961	2978913	3257854
2198023	2641134	2979707	3260122
2207717	2649808	2981061	3261213
2208666	2652778	2982139	3262324
2209735	2666276	2982140	3263507
2219243	2686474	2985022	3264881
2247142	2688805	2995938	3264882
2249744	2691306	2995939	3267747
2253005	2698542	2996922	3267748
2272986	2700829	2997886	3273404
2273309	2708369	3019555	3273405
2292090	2715709	3019662	3273406
2293311	2716943	3025708	3274837
2293707	2720602	3026731	3276267
2308234	2727393	3027471	3276270
2311652	2729106	3043635	3276272

3280643	3446081	3706231	4024769
3283594	3446082	3719092	4030371
3287932	3449962	3722295	4036453
3295379	3449963	3722297	4043205
3299716	3451274	3726146	4147066
3299717	3475975	3727466	4155521
3299718	3477298	3738179	4169391
3301069	3496780	3747417	4189948
3301073	3499333	3753374	4199329
3303706	3503269	3763708	4214482
3309931	3511101	3765250	4240301
3211326	3512020	3789677	4246801
3313162	3516280	3807238	4257280
3320816	3517562	3807239	4258579
3323374	3522737	3823990	4264852
3323376	3526143	3824865	4266432
3323379	3528300	3849896	4267735
3324731	3534617	3854341	4269073
3324417	3535941	3862732	4271709
3339420	3540295	3877317	4274291
3339421	3545287	3878730	4280366
3344676	3570282	3886803	4281555
3354726	3596523	3898668	4283959
3357242	3603161	3898889	4297883
3358514	3604277	3902374	4305304
3359806	3606793	3906804	4320669
3363472	3611815	3908470	4332365
3365958	3625070	3915416	4346614
3365961	3664199	3926060	4351194
3373499	3670585	3931742	4354393
3393569	3672235	3974702	4357837
3412618	3301073	3982441	4366615
3420111	3673875	3985034	4380108
3434354	3677098	4000660	
3434355	3702569	4003265	
3442143	3703831	4021716	

13.57 Rotor or Casing, Pendulous when Stationary, Non-Pendulous when Rotating

13.57.1 Authors

No Entries

13.57.2 G.B. Patent Specifications

511742	682528
542565	707660
549944	733678
556264	944828
582301	950694
655536	996283

13.58 Two or More Rotors in a Single Gimbal Frame

13.58.1 Authors

No Entries

13.58.2 G.B. Patent Specifications

10440-1911	108149	135871	161595
26906-1911	110369	137659	166800
5963-1913	112636	141139	179918
11827-1915	114441	148963	186655
13280-1915	127830	148965	187985
16098-1915	131990	148981	209052
100490	132816	148989	221006
107572	132839	160868	221200

274268	544786	807292	957196
290670	546329	811069	972762
291047	549312	820480	980529
308584	559895	826418	1018679
315966	579991	826419	1034314
322098	627123	839024	1050530
331956	630657	854360	1071371
351030	637993	854506	1173564
371235	657668	866916	1263424
379134	657670	868535	1299822
382343	663437	876433	1425092
435353	706434	884061	1428908
439630	713511	895999	1484793
444715	732975	918524	1521638
462826	733058	924093	1564686
511742	740796	935976	
539011	769247	941533	
544094	791556	942826	

13.58.3 U.S. Patent Specifications

796893	2188606	2752793	2985023
874255	2190390	2758478	2986944
1016240	2242806	2762123	2989672
1050153	2302894	2770452	2995318
1066860	2315500	2771779	2996923
1083370	2320354	2786357	2999390
1150311	2342655	2801544	3001408
1232619	2350303	2811043	3004437
1236993	2371368	2811047	3005352
1309591	2381160	2811785	3020537
1309592	2395250	2821087	3023617
1310862	2403658	2845800	3029646
1310862	2409875	2846889	3039316
1324477	2412614	2848898	3048352
1324478	2414291	2865207	3050995
1330503	2419948	2871703	3052129
1363861	2432613	2871707	3056303
1368226	2441556	2879670	3068706
1429588	2478839	2883863	3069912
1442799	2505021	2886897	3071012
1446348	2507451	2889710	3071977
1452482	2512279	2893248	3075393
1465532	2517612	2898766	3075729
1501886	2539772	2899882	3078727
1529720	2550220	2900824	3104545
1545812	2559094	2906128	3122842
1548442	2566305	2912865	3127774
1573343	2577313	2935942	3131569
1612405	2586469	2936627	3142994
1655247	2591697	2944426	3143892
1687970	2592643	2946539	3143893
1732677	2603003	2948157	3158340
1735058	2606448	2949780	3162052
1801329	2608867	2949785	3163039
1801948	2620669	2953858	3164340
1869840	2630017	2953926	3165927
1930082	2631455	2954700	3192778
1931191	2637914	2955474	3193216
1932210	2643547	2958522	3214983
1947562	2667705	2959059	3220266
1950517	2707400	2960878	3226986
1964869	2713134	2961877	3229533
1973042	2728979	2963242	3229534
1988458	2729107	2963243	3230779
2008058	2729108	2966063	3232122
2137974	2732720	2969681	3238793
2158181	2734280	2970382	3238794
2162482	2752792	2977806	3238795

3242744	3335614	3492735	3762062
3258977	3349630	3493194	3784363
3264883	3352164	3496781	3790766
3266325	3355953	3498476	3805625
3269024	3355954	3509765	3811329
3269195	3377854	3517563	3918309
3272017	3398586	3531998	3931747
3272018	3404571	3540289	3979090
3277728	3424010	3548507	4020702
3280644	3424401	3552216	4021716
3282118	3428789	3563662	4094200
3282119	3438268	3575093	4125017
3285077	3439548	3584513	4152942
3296872	3451275	3597598	4179818
3296873	3452948	3612160	4180916
3304788	3455172	3616699	4193308
3308670	3456512	3638502	4258578
3310986	3456513	3640137	4275605
3318161	3476129	3648525	4280188
3320819	3477298	3691853	4292854
3323380	3481208	3701200	4361055
3327539	3483760	3739646	4387513
3329028	3489004	3741500	4399714
3329375	3490281	3742770	

13.59 Damping Oscillations

13.59.1 Authors

Bloch A. (1964-65)
 Carrier G.F. Miles J.W. (1960/63)
 Filatov V.V. (1973)
 Klimov D.M. (1958)
 Letova T.A. (1965)
 Parks R. Maunder L. (1961)
 Potapov A.A. (1969)
 Sergeev S.I. (1966)
 Sneddon I.N. (1976) see p. 521

13.59.2 G.B. Patents Specifications

340327	612571	918197	1280776
425890	845808	923406	1557528
488601	856374	1096170	2003411
549041	873544	1171719	
587714	889385	1254385	

13.59.3 U.S. Patent Specifications

RE 24741	1773412	2328744	2512902
RE 24829	1866706	2349287	2515274
944511	1988591	2365727	2518632
141099	2013109	2380079	2519459
1162125	2025423	2389775	2520929
1183530	2025640	2395940	2534963
1183745	2046723	2404172	2537844
1308693	2100833	2411550	2544767
1309409	2158048	2412453	2569311
1330501	2190698	2417282	2584222
1407320	2226902	2426213	2585024
1586070	2236340	2432430	2592092
1642087	2242253	2457150	2595268
1655247	2246738	2457228	2599539
1685762	2257730	2464516	2602239
1686524	2279625	2466440	2612692
1713942	2291612	2510068	2625825
1730967	2299663	2512342	2662513
1751110	2503454	2512746	2662514

2667078	2945380	3237459	3548664
2672054	2948155	3240075	3564931
2690014	2951373	3241376	3577646
2693723	2951374	3249321	3582019
2699846	2951375	3250136	3588001
2709921	2952337	3252339	3591108
2712757	2955471	3257853	3592066
27181 '9	2955472	3258976	3596359
2718788	2968953	3260123	3596366
2729984	2982139	3261212	3597983
2734384	2983151	3276268	3608383
2752684	2984114	3286109	3618403
2752791	2984727	3296873	3637169
2754501	2995940	3303707	3653267
2766626	3031892	3310987	3662609
2766627	3037150	3311326	3685770
2780940	3060752	3313163	3716206
2795957	3070192	3324732	3728900
2797581	3071011	3330520	3730457
2802279	3074283	3336812	3784363
2805578	3075393	3340759	3786685
2822694	3079803	3347104	3806062
2825228	3093205	3352163	3877316
2829521	3113594	3353414	3877662
2834213	3115326	3353415	3890718
2836070	3123330	3355943	4043205
2837923	3131903	3396587	4095484
2839932	3132523	3397851	4099696
2839933	3132524	3403191	4126046
2846888	3134265	3406575	4144769
2851886	3136163	3406576	4159502
2852941	3142181	3415479	4161237
2859624	3156121	3417474	4189947
2864256	3162396	3420110	4193308
2865206	3166942	3426980	4198863
2876643	3167966	3430276	4222278
2881868	3172213	3442142	4236414
2887885	3176800	3443321	4240302
2896455	3183724	3464290	4242917
2898538	3186240	3479888	4246801
2899828	3203259	3496202	4255979
2900823	3212344	3497164	4266431
2901703	3214980	3511452	4270393
2902863	3220265	3515007	4352481
2919585	3222936	3523458	4355540
2932546	3222937	3526144	4375726
2937532	3232635	3535941	
2937533	3236108	3540294	

13.59.4 European Patent Specification

EP 0122745

13.60 Datum and Scale Indicators

13.60.1 Authors

No Entries

13.60.2 G.B. Patent Specifications

793173
795053

Datum and Scale Indicators (Indicating means including optical pointers)

9737-1911	397654	565802	718484
15669-1911	405034	566823	726627
19162-1913	411921	572213	731737
9351-1914	413715	573251	733678
24847-1914	414903	574043	734148
5377-1915	415277	578958	737236
106170	416813	579991	751018
120942	417185	580248	751148
123438	418377	582541	760251
125096	419816	583068	769442
125628	421079	583366	777698
127007	422116	590496	790019
127287	425111	591182	802776
127703	425890	591400	805947
127830	426185	592500	806057
128345	435355	593963	835650
129724	437791	595990	840427
130143	441130	599249	865344
131990	442991	599605	876865
133714	445586	599607	885946
134234	453238	599665	885947
139474	455514	604208	886063
139771	457483	605058	892453
140142	461257	607349	900933
140482	462826	608782	947322
142261	463332	608851	985324
142894	464193	609909	990701
145432	471093	612388	990740
145460	471217	612571	996283
146372	471895	616374	1008282
150452	473148	617108	1009169
151154	473688	619939	1014325
155030	474629	619945	1016260
159604	475321	619960	1017590
160316	479279	622185	1018679
164396	485043	623078	1026570
179918	486315	624564	1032473
186159	489232	624947	1034135
187985	494359	625415	1037105
191676	497584	625869	1050530
196296	497952	626635	1068426
196831	500462	629305	1069566
213751	502629	636952	1072365
217405	504753	637993	1083157
218953	504876	638972	1100524
239043	510524	638982	1108391
246741	515176	638983	1117848
248583	521160	641137	1132948
281694	522208	642093	1157966
292051	523947	643613	1162305
294691	520222	648492	1196425
301278	535270	652051	1203841
301571	537137	655138	1207336
309150	537778	660030	1207660
328504	539011	663437	1224825
331627	544094	666432	1231069
341519	544786	666615	1247785
345127	546329	668310	1270567
349026	549042	670983	1278794
351672	550769	682766	1284700
359071	551169	682908	1301781
361836	551823	684667	1323864
382782	553730	684668	1396163
390410	555177	708969	1410895
391111	556264	712888	1411201
393354	561018	713511	1477603
393695	562886	717322	1505519

1564686
1579920

13.60.3 U.S. Patent Specifications

3301074
3371542
4553440

13.61 Correct Operation and Understanding Errors

13.61.1 Authors

Blokhin A.N. Saprykin A.P. (1978)
Bachkalo B.A. (1974)
Crawley J. Maunder L. (1964)
Chelpanov I.B. (1973)
Forder P.W. (1985) (relativistic effects)
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Gilstad D.W. (1973)
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Tereki I. *hatvani L. (1982)
Vlasov Yu. B. (1974)

13.61.2 G.B. Patent Specifications

687135	880299	1029012	1331150
717322	895999	1057743	1339683
723377	911490	1061769	1346558
778533	917168	1066914	1425854
798485	925219	1075221	1508376
804006	925576	1081505	1511430
810279	926959	1089070	1553488
820480	950694	1096831	1557528
844948	957163	1119324	2014309
857552	964648	1212287	2019617
865642	983658	1299031	2113430
874101	1019720	1308205	

Devices Indicating Correct Operation

130095	645408	731737	964648
131992	708969	745186	1061769
133714	717322	751403	1092162
141139	726627	761521	1092344
143969	726849	831336	1096831
152008	726890	860171	1097682
419816	729008	944828	1103621
530582	729518	954312	1134273

1146833	1308205
1173564	1346558
1176228	
1176735	
1292287	

13.61.3 U.S. Patent Specifications

3368411	4088031	4269073
3540294	4126046	4270387
3731543	4189947	4351194
3965753	4266432	4354393
4026160	4267735	

13.61.4 German Patent Specifications

2363525
2366101
2527464

13.61.5 Russian Patent Specifications

442375
532052
534015

13.61.6 European Patent Specification

EP.0127843

13.62 Pick-off Devices

13.62.1 Authors

Monopoli R.V. (1961)
Vyce J.R. (1965)

13.62.2 G.B. Patent Specifications

560472	879533	1069080	1486189
591022	827112	1086539	1526139
599826	938705	1104525	1564105
612507	940790	1150134	2061515
743251	953407	1152585	2079954
751018	971613	1312294	2113430
793649	980487	1314304	2176283
841944	988898	1364055	
867866	1047999	1399607	

13.62.3 U.S. Patent Specifications

2200431	3045197	3807239	4143466
2381645	3078729	3811328	4361760
2490735	3097299	3813949	4361054
2737054	3154952	3905244	4296639
2805677	3252338	3918310	4329884
2856778	3320816	3915019	4339959
2925590	3608383	4068533	4355541
2986944	3779087	4074580	

Gyroscope with Pick-off

1236993	1419010	1621835	1959144
1295003	1446280	1639233	1959804
1318196	1500860	1745990	1982442
1324477	1529720	1801609	1992086
1335055	1592081	1860230	1998948
1392378	1597788	1900709	1999646

2008058	2553268	2951378	3429190
2041526	2562690	2956436	3438270
2089987	2602239	2968957	3442143
2103741	2605368	3005351	3444744
2115578	2620570	3045197	3452444
2137974	2633028	3058358	3452601
2162482	2641134	3122937	3456511
2183133	2644901	3123818	3456512
2195351	2690014	3125886	3463016
2200431	2691306	3142993	3469458
2228367	2697218	3149276	3470751
2237077	2704457	3162804	3475971
2320354	2709922	3177727	3477298
2345071	2712757	3194079	3479889
2361458	2713727	3198021	3481207
2363495	2718780	3209602	3489017
2381160	2722125	3218872	3498144
2382993	2725750	3222552	3505882
2385203	2730664	3224281	3509779
2386176	2753718	3226711	3512264
2389158	2754465	3239673	3517562
2393473	2754789	3241377	3522395
2401337	2779214	3250137	3526144
2403874	2785573	3252340	3527108
2407657	2787909	3258976	3533297
2409634	2797376	3260122	3540289
2414102	2798995	3261213	3540293
2416646	2802918	3262324	3561129
2417689	2814743	3276271	3587330
2421247	2814955	3277727	3610051
2425733	2815584	3277728	3611785
2429612	2821859	3279263	3613457
2434488	2823326	3285076	3614895
2440189	2841751	3286533	3657918
2440713	2846891	3295379	3702078
2450874	2847664	3307412	3722297
2456619	2865205	3307413	3732739
2461521	2875618	3311326	3741020
2463095	2878006	3313162	3782205
2463498	2881618	3319474	3787100
2465311	2893247	3324731	3790235
2478956	2904911	3338105	3813946
2480574	2928667	3345520	3815428
2484022	2929250	3347105	3883788
2485953	2933925	3365961	3883957
2488734	2942475	3377872	3968352
2501885	2948155	3379889	4111562
2511178	2949784	3412472	4189946
2537844	2951376	3425015	4258577
2539772	2951377	3425283	

- A Optical Pick-off
 B Pneumatic Pick-off
 C Conducting Liquid Pick-off
 D Electrical Pick-off
 E Electrical and Magnetic Pick-off

A			
1972882	2954700	3228628	3328595
1999646	2959060	3238791	3355953
2200431	2968954	3254537	3367194
2392473	3071676	3270567	3373616
2470773	3084560	3277304	3415126
2512598	3097299	3292439	3417627
2534824	3142183	3301071	3422686
2856238	3154953	3304788	3439170
2856778	3200510	3313161	3439547
2942479	3205718	3323375	3442144
2948813	3226982	3323377	3449961

3457794	3585877	3813949	4068538
3499332	3592066	3877317	4155521
3501966	3596523	3905244	4170904
3501967	3603161	3915019	4264852
3528299	3628385	3924475	
3551997	3703832	4027540	
3565495	3798976	4036453	

B

1419019	2709921	3354727	3604277
1521132	2852942	3362233	3610053
1592081	2871704	3362234	3610054
2129586	2960873	3382726	3620089
2200196	3021714	3386293	3625069
2227371	3139758	3410143	3625070
2257077	3165282	3416378	3672235
2273117	3187588	3435688	3702079
2315167	3250497	3446082	3747418
2345169	3265335	3451289	3811328
2427549	3267747	3465600	3933051
2428345	3276270	3485106	394696
2498285	3311987	3486384	3974702
2569676	3320816	3492879	4000660
2584125	3323378	3509778	4088031
2605093	3340740	3577788	4297905

C

RE 27195	2478956	2871703	3226984
1228061	2713727	2947177	3226985
1655800	2720115	2953027	3299716
1687970	2780940	2973413	3362232
1763806	2795957	2998728	3428789
1887318	2802918	3026731	3430501
1942737	2825228	3060751	3543587
2041526	2825789	3083578	3704406
2417573	2834214	3142991	3704407
2427130	2834215	3200653	
2446180	2841016	3208288	
1456020	2868023	3225608	

D

1324128	2677514	2909831	3148550
1324478	2701875	2911832	3158033
1446348	2703935	2919585	3160918
1558514	2707401	2925590	3176523
1981687	2715709	2925736	3188540
2270876	2723813	2957533	3191445
2278379	2746301	2948156	3197756
2349287	2752791	2951326	3222937
2368644	2766627	2951373	3225607
2410473	2785573	2951374	3226983
2423270	2790119	2955473	3234798
2438306	2794345	2964952	3240860
2464592	2804776	2973650	3241389
2472824	2810843	2976736	3251235
2477574	2817240	2978622	3251238
2479122	2822695	2982139	3252339
2484022	2829522	2991659	3261006
2509446	2837924	3052832	3263506
2547968	2852943	3058359	3267746
2567682	2856779	3060752	3270566
2570298	2879669	3078728	3282081
2592417	2887636	3078729	3285026
2595951	2893246	3082628	3290948
2606310	2894395	3097535	3301072
2628502	2895098	3107540	3309931
2635469	2902863	3135121	3320817
2669126	2908168	3147627	3324732

3327541	3505883	3882731	4098564
3350947	3522736	3883958	4111067
3354726	3524356	3886805	4121143
3359805	3524357	3891285	4143466
3359806	3526145	3902376	4150579
3363169	3545287	3906804	4158312
3375722	3557629	3908470	4170904
3394597	3559492	3918310	4179087
3413859	3608383	3933051	4217787
3430500	3664199	3935644	4255978
3434353	3670578	3951000	4258577
3439546	3670585	3954026	4267737
3439556	3678764	3955428	4281555
3440889	3779087	4019392	4320669
3444745	3787756	4061043	4329886
3482455	3802276	4068333	4335927
3483761	3815428	4068909	
3490297	3824865	4074580	
3491453	3847028	4095477	

E

2697218	4167296	4257280
2719291	4170904	4259871
3891285	4185797	4266432
4019392	4189948	4267737
4152942	4191346	
4158312	4240301	

13.62.4 Russian Patent Specification

596825

13.62.5 European Patent Specifications

EP.0009347

EP.0207907

13.63 Balancing

13.63.1 Authors

Beaulieu A. J. (1973)

Den Hartog J. P. (1963)

Kear F. W. (1960)

Kovalev M. P. et al i i i (1965)(1962)

IBM Technical Disclosure Bulletin

13 No.6 (1970)p1483

13.63.2 G.B. Patent Specifications

548826	603038	1284195
568499	612357	1340462
570170	655151	1476573
581991	1015681	1564105
593231	1156637	2007840

13.63.3 U.S. Patent Specifications

1180815	2826918
2118770	3147624
2618159	3285076
2650502	3935746
2714311	4003265
2735305	4028524

13.63.4 French Patent Specification

2363780

13.63.5 Russian Patent Specifications

462098	588481
515954	664074
552505	
567982	
577419	

13.63.6 European Patent Specification

EP. 0161153

*13.64 Temperature Variations**13.64.1 Authors*

Barnaby R.E. ii (1961)
Marshall R.E. Jansson R.M. (1960)

13.64.2 G.B. Patent Specifications

163315	511745	594465	1069594
164285	542613	631794	1084456
237366	544728	633942	1179601
388169	561297	977873	1306792
391111	574582	1018509	1557528*
474020	579909	1025325	

Temperature variations, compensating for or preventing

15669-191	550769	764644	885303
2120-1913	561297	791556	886063
170947	566655	798089	911913
387366	574582	798107	918197
388169	579909	812875	958988
391111	594465	815556	959258
425954	603427	825917	960437
463332	616374	845808	973122
466864	630657	847278	977873
471537	640562	852562	938658
474020	706434	856374	996283
511745	740349	868535	1024625
537777	740350	876433	
542613	740785	878029	
544728	753449	879685	

13.64.3 U.S. Patent Specifications

3004436	3240074
3112651	4603483
3132523	4651576
3186240	
3200653	

13.64.4 European Patent Specification

EP. 0142937

*13.65 Unclassified (Testing)**13.65.1 Authors*

Matasov A.I. (1985)

*extensive prior art given.

13.65.2 G.B. Patent Specifications

245546	564752	964648	1086299
271528	574257	1008375	1094396
526279	612557	1053077	1095519
547022	635192	1054238	1096831
558374	756504	1061769	1173564
562688	880299	1064219	
565382	957163	1066450	

13.65.3 U.S. Patent Specifications

2468137
3077760
3194051
4646255

13.65.4 Russian Patent Specification

676868

13.66 Horizontal Gyroscopes

13.66.1 Authors

No Entries

13.66.2 G.B. Patent Specifications

No Entries

13.66.3 U.S. Patent Specifications

195860	1707475	2292090	2968956
392246	1736039	2334002	3212196
812587	1741736	2401160	3386179
875036	1749059	2405047	3452444
1092816	1801947	2478956	4267737
1197134	1825345	2588607	4275604
1279471	2129586	2609615	4283960
1358258	2219964	2677194	
1695774	2274443	2940318	

13.67 Vertical Gyroscopes

13.67.1 Authors

No Entries

13.67.2 G.B. Patent Specifications

No Entries

13.67.3 U.S. Patent Specifications

157053	1522008	2176203	2874576
366438	1524788	2188606	2886972
464806	1545372	2190698	2968955
595820	1586670	2200196	3193216
640051	1586071	2249744	3196694
678757	1679354	2270876	3226986
919064	1709314	2293039	3238792
1141099	1726643	2315167	3311326
1313532	1731776	2378744	3455172
1342397	1932210	2405058	3466935
1380335	2027808	2418032	3498145
1393845	2041526	2437251	3543587
1447685	2133793	2590207	3587330
1480637	2162698	2745091	3604276

3606794	4088031
3648525	4158312
3664200	4266431
4043614	4294128
4061043	4297905
4068533	

13.68 Self Excitation of a Gyroscope

13.68.1 Authors

Arnold R.N. Maunder L. (1961) p 196 et seq.
Leimanis E. (1965) see p 136
Magnus K. vii (1975)
Maunder L. iii (1964-65) see p 13
Morante A.B. (1968)
Merkin D.R. ii (1959)
Quartley A.L. (1957)
Smol'nikov B.A. Stepanova M.V. (1981)

14. THE GYROSCOPE IN NAVIGATION

14.1 General

14.1.1 Authors

Bogdanovich M. M et al (1961)
 Bulgakov B.V. (1969) a reprint of his important paper of 1938
 Dubois E. i ii iii (1872) (1884)
 Ishlinskii A. Iu. iii vi viiiA (1957-1959-1965) viiiB
 Ledieu A. (1872)
 Maunder L. v (1968)
 Nitsov E.V. (1972)
 O'Hara W. (1951)
 Rivkin S.S. (1965)
 Ryabov B.A. (1963)
 Thomson W. iii (1884)
 Topelbert D.G. (1950)
 Usener H. (1917)

14.2 Gyromagnetic Compass

14.2.1 Authors

No Entries

14.2.2 G.B. Patent Specifications

9737 of 1911	571036	638972	874992
125791	571622	638982	877270
366764	574848	638983	895576
404994	576412	639391	900933
408121	586506	642093	930695
422116	586507	642649	934430
440980	587925	655138	942060
461257	587932	668401	942772
46686	591019	668431	955911
466865	600165*	671411	974675
468672	600186	676005	1027230
490162	600189	681926	1043597
501836	600605	682766	1043597
505495	601663	685480	1058755
505715	601971*	690011	1126463
505900	603448	691846	1288290
505901	605646	711078	1332168
510789	606955	713289	1339070
513624	607117	723486	1358417
520286	612307	747207	1416967
522384	612388	749012	1431432
529459	616538	756637	1480652
538346	619525	769442	1512788
538943	621014	772090	1555286
539225	624201	794076	2057127
549042	624406	806083	2056685
553178	627978	827199	
554595	627979	850692	
559327	631794	854732	

Gyro-magnetic compasses

270006	405121	466864	490162
298934	419934	466865	501856
366058	440980	473799	504753
366764	444393	475372	505495
377262	444827	482389	505715
404994	460491	487299	505900

*historical review etc.

505901	580445	622185	711078
510789	586506	624201	732975
529459	586507	631794	733058
535211	587925	638971	756637
538346	587932	638972	769442
538943	600186	638982	790031
539225	601131	638983	812294
542529	601663	639391	874992
544786	606646	642093	877270
545284	606955	655138	900933
546329	607117	676005	942060
554595	612307	682766	1126463
565351	621014	691846	1416967
576412	621018	698033	1512788

14.2.3 U.S. Patent Specifications

1617	2451230	2959866	3911255
2357319	2561367	3091127	3967384
2361790	2574471	3559493	4010549
2412614	2852859	3331286	4180916
2415813	2887873	3837086	

14.3 Earth Inductor Compass

14.3.1 Authors

No Entries

14.3.2 G.B. Patent Specifications

194686	507965	588482	662832
298934	539817	601971	668431
314786	549028	619525	685480
342038	549528	624083	690011
366764	550779	624406	695880
389819	565351	627978	756085
396547	569839	638972	790031
400040	574848	638982	794076
506458	583366	662831	

14.3.3 U.S. Patent Specifications

2176197
2737054
4013946
4197655

Direction Indicators

34298	1610930	1973042	2086898
366938	1612405	1974220	2092032
464806	1617310	1975740	2093417
595820	1628136	1981687	2099705
640051	1642087	1982851	2105148
741683	1655247	1996895	2106194
841612	1688559	1996896	2111388
877034	1727460	2000524	2114479
940329	1851536	2001038	2129586
1031769	1857736	2005379	2133489
1032022	1860345	2008058	2133809
1067808	1880994	2015650	2136944
1124068	1901567	2018735	2166920
1324128	1903710	2038537	2173228
1342397	1922976	2047922	2175165
1451928	1924339	2052866	2178623
1489512	1924816	2061894	2180221
1493473	1929400	2069285	2230196
1522924	1937336	2075797	2213708

2203824	2405058	2704457	3463909
2208207	2406341	2707882	3475975
2208666	2411087	2730813	3480766
2210090	2416646	2735191	3487553
2214538	2427130	2745091	3491228
2219267	2427158	2811785	3509765
2219964	2433837	2816448	3518016
2220457	2437251	2823464	3543587
2226191	2443076	2847664	3577646
2227529	2470482	2854763	3597598
2249373	2478956	2857677	3633003
2261945	2511869	2864174	3731543
2273876	2512598	2882718	3806865
2292451	2513529	2958953	3816935
2293039	2519422	2988818	3849896
2293092	2532104	3019532	3883957
2303641	2533686	3032886	3889387
2315500	2548918	3142183	3911255
2321543	2555328	3197881	3930317
2324157	2567053	3197882	3938256
2333984	2567682	3199207	3962797
2334116	2569473	3239166	3977087
2335876	2572827	3250497	4020491
2337602	2609615	3253472	4027540
2345915	2611190	3363169	4071959
2349757	2633028	3365147	4143466
2360399	2637914	3371542	4158261
2360935	2642885	3386170	4180916
2366543	2655046	3391568	4197655
2368221	2666199	3392698	4218827
2368628	2666268	3394596	4244116
2383409	2667698	3423051	4370815
2384452	2674049	3426592	4373126
2387104	2681576	3436967	4384409
2403874	2688805	3440889	4393597
2404603	2699611	3453894	4416066
2405052	2700106	3460486	

14.4 Gyri compass

14.4.1 Authors

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 Reid R.E. (1984)
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 Rellensman O. Pfeider E.P. (1959)
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 Schuler M. i ii iv v vii xii (1909-1935)
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 Tokar' E.N. (1961)
 Usener H. (1917)
 Vasilenko V.P. Temchenko M.E.
 Vavilov S.M. (1983)
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 Watt G.J. (1964)
 Williams H.S. (1907)
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14.4.2 G.B. Patent Specifications — Gyro-Compass

1184 of 1856	10382 of 1908	12959 of 1914	124529
2676 of 1857	22602 of 1909	22379 of 1914	124533
6842 of 1884	23575 of 1910	24847 of 1914	124825
8394 of 1884	9691 of 1911	565 of 1915	125660
1122 of 1889	9737 of 1911	1240 of 1915	126751
1031 of 1890	10440 of 1911	16095 of 1915	127830
3587 of 1899	15669 of 1911	17725 of 1915	128236
25984 of 1903	14339 of 1912	100490	129708
2695 of 1906	27739 of 1912	104191	129724
10184 of 1906	29082 of 1912	107572	131987
10185 of 1906	26068 of 1913	108149	131990
15942 of 1907	26160 of 1913	112636	132816
20562 of 1907	2735 of 1914	114441	132839

* deals with Geckeler's equations

**refers to some early German patents

137059	303229	629104	1072365
137205	308584	629150	1095131
139142	309860	635192	1098827
139474	309910	638971	1111456
148374	319250	668401	1117848
148963	320355	691846	1152447
148964	30380	706434	1176735
148965	331956	707446	1183034
148967	331972	707518	1186642
148981	342880	708873	1196425
148963	346466	713511	1203841
152090	353296	717470	1207660
152226	367692	751142	1224512
153588	371807	772432	1224992
153589	397654	772433	1259753
154618	405034	776610	1278864
157986	414903	798089	1280652
160868	417995	801636	1280776
166570	433494	804372	1284492
166571	435399	805038	1319398
166868	448763	807292	1339683
166906	460244	808075	1385819
170947	461257	811031	1396163
172029	461424	825917	1400488
175292	472779	825918	1410895
177153	482215	825919	1413745
179918	504726	825920	1424588
180413	505007	829169	1425092
188390	507643	839024	1469123
206541	509178	885946	1505519
209052	509602	885947	1549043
210062	539011	902264	1564686
215594	542529	923406	2011617
218358	544094	954312	2111202
229869	547440	957196	2057127
244843	583786	985324	2070244
245546	597188	1009165	2090973
247265	600661	1016260	2094975
255745	603430	1030706	2100428
265554	612723	1032473	2104217
269042	617918	1039106	2111202
275182	620042	1048615	2139350
290392	627291	1057743	
290670	627686	1068426	
296790	627969	1069566	

Gyrocompass — avoiding or reducing ballistic errors

131987	275182	509178	804372
152090	290392	509602	811031
159604	290670	547440	839024
175292	303229	603430	885946
179918	309910	612723	885947
188390	309924	663437	959562
210062	319250	707446	1098827
215594	371807	708873	1425092
218358	448763	772432	
255745	472779	772433	
265554	504913	791556	

Gyrocompasses — avoiding or reducing damping or latitude errors

247265	612723	1183034	1410895
460244	791556	1207660	1416967
474718	804372	1224512	1554204
482215	825917	1224992	1554205
504726	825919	1396163	1555286
603430	1032473	1400488	1580092

Gyrocompasses — avoiding or reducing rolling errors

10440-1911	131987	166570	707446
26160-1913	131990	175292	713511
2735-1914	137059	188390	772432
10095-1914	139142	209052	772433
14486-1914	139474	210062	791556
16098-1915	148374	269042	825917
100490	148963	308584	859024
107572	148965	353296	1396163
108149	148981	507643	1413745
110369	148989	539011	1425092
125660	165221	549312	1576631

Gyrocompasses — avoiding or reducing speed and course errors

15679-1911	210062	583786	1183034
24847-1914	218358	693430	1207660
135664	255745	663437	1339683
145461	258646	798107	1396163
154618	330541	804372	1416967
155257	371807	825917	1424588
175292	383164	825919	1425092
179918	433494	939024	1469123
188390	461424	1009169	

Gyrocompasses — with movement of the rotor axis about the meridian damped by air and other fluid jets.

112636	303229	509178	707518
126451	460244	544094	772432
157986	482215	553194	772433
166570	504912	606335	798089
166571	505007	707446	798107

Gyrocompasses — with movements of the rotor axis about the meridian damped by interconnected liquid containers

11028-1911	188390	290670	549312
124529	192381	319250	751142
125660	206541	353296	807292
129708	209052	367692	957196
131987	210062	371807	1069566
135500	215594	383164	1183034
152090	218358	448763	1186642
153589	229869	460244	1207660
157986	258646	472779	1224512
159604	265554	479279	1564686
166570	269042	482215	
177153	275182	509178	
179918	290392	547440	

Gyrocompasses — with movement of the rotor axis about the meridian damped by pivoted ball with eccentric connection to rotor casing

15669-1911	348517
26160-1913	663437
157986	1186642
215594	
342880	

Gyrocompasses — with movement of the rotor axis about the meridian damped by unclassified means

9737-1911	17725-1915	175292	583366
27739-1912	106170	179918	603430
6570-1913	127055	180413	607195
11988-1913	127830	405034	612723
26068-1913	137059	414903	627291
22379-1914	148967	435399	682908
16098-1915	166570	504913	751142

791596	1152447	1259753	1555286
839024	1175863	1280776	1564686
985324	1183034	1410895	1579920
1069169	1196425	1554204	1580092
1037106	1227130	1554205	2002116

Gyrocompasses -- with movements of the rotor axis about the meridian damped by weight attached rigidly, resiliently or pendulously to rotor casing

1240-1915	706434	886063
127055	707446	1032473
166868	708873	1095131
206541	798089	1207660
346466	825917	1416895
405034	825919	1555286

14.4.3 U.S. Patent Specifications

1309636	3229376	4008623	4283960
1925138	3292269	4143466	4471665
2677194	3296623	4158261	4504857
2734280	3373617	4214482	4530164
2811047	3452443	4275604	

Gyrocompass

1136566	1527932	1886606	2158048
1226882	1625361	1887318	2257730
1242065	1626123	1972882	2363500
1255480	1647419	1978425	2342655
1279471	1725317	1984874	2431304
1343188	1728185	1998948	2419948
1362842	1730967	2024621	2422687
1412760	1777958	2043168	2441556
1419010	1782048	2095313	2510068
1499321	1784348	2110766	2611973
1493214	1805854	2134932	
1493215	1811415	2129818	
1518740	1831598	2142018	

Gyroscopic Compass

894659	1308692	1473103	1671583
913611	1308693	1481213	1677331
1018582	1309409	1493214	1678436
1067808	1309591	1493215	1686518
1074771	1309592	1495769	1686524
1092816	1309637	1496087	1728185
1136566	1311716	1496950	1730867
1186339	1330501	1497660	1734129
1186696	1343199	1497371	1739251
1221477	1362940	1498322	1743533
1221345	1367834	1498602	1744069
1222802	1378296	1500239	1746832
1233527	1378620	1503436	1749059
1240872	1380335	1512222	1751110
1242065	1380336	1518740	1765548
1250542	1385423	1518762	1773172
1253480	1386029	1541775	1773411
1260097	1386030	1589039	1773412
1273759	1403062	1617380	1777601
1273799	1412760	1621835	1778958
1274471	1419010	1625361	1780019
1289813	1425194	1626123	1784048
1291695	1425517	1628136	1793142
1294990	1445278	1644321	1801619
1300890	1445405	1647418	1805454
1308683	1452465	1650162	1811300

1811415	2110766	2735191	RE15072
1831598	2124559	2739390	RE15924
1834341	2129818	2802279	RE26370
1834642	2134932	2811706	3292269
1837292	2142018	2821791	3321841
1850982	2157360	2887783	3346966
1850869	2158048	2887794	3373499
1854877	2249562	2902172	3386179
1864801	2249345	2922220	3405451
1866706	2255899	2970382	3419967
1866733	2257730	2972195	3443320
1886606	2263232	2976618	3443321
1890831	2273769	2992623	3451139
1895628	2273808	3049808	3452443
1917017	2281286	3077672	3461568
1920291	2295254	3098306	3492735
1922976	2302899	3099094	3492736
1923885	2342655	3122842	3501844
1924688	2406979	3146530	3512264
1925136	2412614	3172213	3518771
1930082	2418816	3173215	3542444
1932412	2431369	3173216	3545092
1950517	2441556	3206864	3555692
1962749	2510068	3212196	3561129
1971510	2611473	3222794	3577646
1972882	2615258	3225452	3596366
1978425	2637919	3229376	3706137
1986801	2644244	3231984	4180916
1998945	2662301	3237313	4442723
2011436	2677194	3254418	4458426
2024621	2682115	3269024	4471665
2044899	2682441	3274696	4472975
2070923	2700829	3279086	
2095313	2734280	3290787	

Gyroscopic Compass Telemetry System Combined

526220	2036571	2418685	2866180
642662	2045042	2419573	2880409
827182	2051902	2425366	2909764
910287	2089701	2426383	2932014
998872	2147423	2427180	2937369
1208026	2154250	2443623	2943302
1213723	2155420	2444624	2979704
1281613	2200378	2448783	3024448
1443166	2210317	2452249	3246304
1479663	2211711	2461425	RE21372
1483235	2274709	2463681	3302191
1657910	2250639	2464612	3366941
1713850	2256473	2465241	3474434
1715511	2273596	2502786	3513460
1729136	2294741	2550945	3518652
1755340	2314719	2564416	3530449
1768552	2326200	2643332	3576554
1885074	2330508	2698428	3593335
1898182	2333406	2712127	3603946
1902052	2359005	2712645	3611332
1950092	2365430	2745027	3613060
1953114	2360281	2749534	3653013
1992700	2374439	2771596	3671952
2004421	2391057	2816279	3827037
2020526	2391058	2845612	3882474
2024318	2399903	2862200	

14.5 Gyroscopic Steering of Ships

14.5.1 Authors

Gray J.G. iii (1914)

Henderson J.B. iii (1934)

14.5.2 G.B. Patent Specifications

5453 of 1913	341592	436579	608039
18101 of 1913	342323	448959	636117
29661 of 1913	350375	458090	642403
145741 of 1914	355566	475372	656518
15777 of 1914	366058	478344	957948
117827	377262	490313	1176913
185162	382222	523513	1223986
247633	411620	535211	1319398
323195	425009	590641	

14.5.3 U.S. Patent Specifications — Ship Steering

15898	515548	1015061	1592081
17525	537124	1015837	1603867
RE27420	550001	1041103	1612434
53934	550018	1043500	1617310
137574	559244	1055814	1678714
148434	559904	1088503	1679395
156320	561272	1091653	1681415
158101	561273	1093196	1684307
162709	568737	1100420	1695601
173951	596179	1128661	1695615
186424	602684	1134919	1702404
189459	603038	1151867	1711126
189972	613869	1154103	1729869
194658	622398	1164038	1730951
196566	624531	1175959	1757096
212950	626009	1200288	1765583
233876	626951	1228364	1772787
244541	635951	1270176	1776118
270344	649771	1293167	1785971
277667	654130	1306552	1793433
283259	702980	1332302	1801947
284325	714081	1345060	1813103
292599	714786	1360258	1825240
293755	716468	1360276	1835453
313901	739775	1360325	1838965
313907	743115	1360694	1871469
315758	748252	1361127	1876731
317817	759536	1365347	1890293
319665	769916	1387850	1903265
333008	771537	1389347	1911168
352374	774693	1392786	1912489
368796	810634	1392787	1927935
385259	811852	1403318	1930945
404472	812306	1405078	1939775
418032	884292	1406405	1946693
418921	884294	1418794	1948487
423194	887443	1436280	1957647
471202	887701	1442041	1958258
476022	905871	1451064	1958259
478814	911069	1461841	1958428
482421	914626	1465091	1968542
493000	916893	1467763	1982702
495047	929174	1488723	1988463
498160	942952	1497059	1993548
500359	950818	1517575	1993549
509644	969084	1522833	1993550
512662	978746	1536996	1993551
515286	980156	1569927	2015186

2023334	2343313	2753498	3199482
2066194	2351977	2796576	3203390
2068065	2352649	2796737	3206998
2073203	2360361	2797579	3208300
2074251	2361178	2806441	3217683
2087647	2362178	2809435	3220373
2089914	2363335	2819777	3225620
2095031	2365490	2819778	3225730
2099713	2369456	2823636	3232262
2102513	2377698	2834565	3237583
2104627	2382727	2841754	3237584
2112171	2391645	2864990	3238957
2112504	2392056	2873710	3249080
2116103	2398243	2875722	3259080
2120950	2400701	2888896	3259094
2121894	2401771	2891205	3263639
2131951	2402724	2894473	3263640
2133153	2403658	2895445	3274849
2134757	2403669	2903822	3277431
2136213	2404281	2909140	3280781
2140713	2408929	2909940	3290881
2145493	2412486	2914013	3319594
2155055	2420154	2914020	3330242
2155075	2422139	2920599	3336891
2156976	2427549	2925060	3358633
2158584	2433826	2927551	3359823
2159142	2434178	2928291	3363599
2163724	2434187	2934690	3386313
2168112	2440713	2940409	3386406
2175627	2445940	2945170	3393656
2175799	2448778	2947273	3417723
2175800	2458177	2949093	3417726
2176203	2470137	2951460	3450087
2176469	2495536	2958024	3465221
2176807	2498223	2961986	3505577
2179179	2499471	2976833	3508512
2182717	2504139	2979006	3527186
2185074	2508803	2987027	3530819
2188834	2516168	2989021	3542048
2194217	2523636	2993464	3545398
2195351	2532402	3003450	3556033
2195406	2541765	3018750	3576977
2200431	2543553	3026545	3580206
2201226	2583059	3041995	3588796
2216097	2583407	3050025	3596163
2222275	2585389	3051886	3598947
2232982	2590029	3066635	3603167
2237834	2601791	3068828	3604907
2238029	2614438	3080953	3613624
2247294	2629356	3084566	3641962
2257203	2634067	3085447	3660743
2257757	2641213	3088330	3673977
2262931	2666746	3106903	3676648
2266410	2667746	3111105	3678878
2294906	2667934	3118321	3685478
2298653	2667939	3127864	3688727
2304430	2668514	3129686	3695205
2307781	2683434	3131340	3696282
2308430	2702615	3133520	3699420
2319435	2713316	3138133	3715571
2324882	2714362	3139254	3715890
2333602	2716960	3140436	3737635
2334882	2719502	3140843	3739738
2337589	2725841	3143994	3760755
2337602	2726621	3143995	3761791
2339023	2736856	3146654	3762352
2340174	2740306	3167698	3765361
2340175	2742735	3171383	3771483
2340524	2743624	3180298	3774568

3796058	3943878	4099476	4314520
3796178	3945201	4106426	4318700
3796292	3955438	4173937	4322208
3798525	3972301	4185473	4323353
3802372	3982493	4188904	4327658
3807339	3983834	4201146	4334489
3810440	3986475	4203380	4334491
3811394	3989000	4211180	4352666
3811395	3995576	4220111	4362515
3815537	3996875	4225148	4366767
3832967	4003328	4227481	4367658
3838656	4004536	4228756	4390206
3847107	4004537	4231308	4392446
3852650	4009678	4241684	4398486
3857353	4013034	4244316	4405630
3861348	4014281	4262618	4408772
3865063	4040375	4262619	4413583
3867712	4041886	4263994	4416636
3870007	4041889	4266497	4417879
3888201	4051801	4294184	4418633
3900198	4054102	4295833	4419084
3929086	4080918	4300888	
3940674	4088087	4307677	

14.6 Inertial Navigation

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14.6 2 G.B. Patent Specifications

835312	994896	1094111	1219862
854393	1018509	1101934	1288118
856685	1023554	1109615	1343598
909477	1024625	1113642	1344404
917452	1026764	1118663	1353285
921740	1028122	1120181	1356667
924093	1040004	1135117	1394663
955175	1044363	1135118	1421620
962669	1047949	1149435	1480652
971852	1050530	1200029	2004368
972762	1054082	1200955	2029606
976517	1055338	1202456	2056062
978710	1075277	1203841	2130377
979580	1078356	1204763	2169727
980630	1078357	1212876	
994489	1092162	1213407	

Ine. of navigation systems

411124	863456	980630	1071371
448051	863457	986318	1075277
541705	863458	988089	1078456
698733	866473	994465	1078357
731561	876424	994489	1078358
749988	880299	994896	1079310
762301	892969	1009506	1092162
762346	895999	1016943	1093549
798107	909477	1024625	1093550
816779	938957	1026764	1094111
820480	942826	1028122	1101934
826417	945302	1034314	1111456
826418	955175	1040004	1118663
826419	956264	1040392	1120181
826420	962669	1044363	1121899
826421	971852	1047999	1135117
833400	972762	1050530	1135118
834506	976517	1051905	1141384
835312	978710	1055338	1141385
856685	979580	1064219	1149435

*re. Kalman filter

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1178703	1216072	1318872	1467559
1197253	1219862	1343598	1481839
1200029	1275880	1353255	1521638
1200955	1278854	1375147	1536344
1204763	1283118	1394663	
1204899	1297429	1411201	
1212876	1299822	1421620	

14.6.3 U.S. Patent Specifications

1735058	3306115	3672229
2953522	3307411	4125017
3028592	3307412	4179087
3148550	3359805	4179818
3304788	3442140	

14.6.4 International Patent Specification

W0 86/00158

14.7 Land Vehicles

14.7.1 Authors

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14.7.2 G.B. Patent Specifications

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825918	2002116	2041319	2088553
825919	2005841	2049931	2104217
825920	2020019	2053471	2106245
1551309	2023294	2064116	2124372*

14.7.3 U.S. Patent Specifications

2677194
3844451
4442723
4461089
4530237

14.7.4 Germ Patent Specification

2545025

*Mathematical dissertation

15. THE GYROSCOPE IN THE AERONAUTICAL SCIENCES

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15796 of 1907	19830 of 1909	5070 of 1911	135267
11897 of 1908	20962 of 1909	5071 of 1911	136168
13809 of 1908	25953 of 1909	9706 of 1911	156818
16606 of 1908	3732 of 1910	20049 of 1911	160523
21656 of 1908	15576 of 1910	23194 of 1911	164020
23595 of 1908	19779 of 1910	23271 of 1911	166907
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978 of 1909	24351 of 1910	29117 of 1911	185162
3908 of 1909	24352 of 1910	29395 of 1911	196296
5699 of 1909	24400 of 1910	27062 of 1912	212544
8350 of 1909	25749 of 1910	18515 of 1913	227489
8432 of 1909	27871 of 1910	9370 of 1915	273770
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9828 of 1909	30210 of 1910	12288 of 1915	302630
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349733	601132	698032	965490
365186	602320	698033	974864
365187	603221	708345	975931
365188	603383	712993	978141
365189	608039	715312	983096
365190	611008	715313	983649
368281	611029	715333	984584
377237	611030	729241	984585
379109	611037	739865	985137
395689	611039	740696	995625
397805	612247	749990	997707
402345	612436	760683	998766
411921	612804	767069	1000515
413948	616702	777730	1002340
419882	617240	790637	1003567
419934	618411	793274	1005797
422813	618456	793795	1010808
425009	621121	796056	1012727
427422	622105	798485	1015326
433404	622926	800882	1020185
436579	624407	802536	1021801
444827	624554	802672	1024834
448959	624996	806057	1026881
458050	626285	806083	1032466
468288	626287	806049	1035440
468487	633500	809278	1036721
475372	635870	812748	1042170
482389	636328	813297	1044834
489032	637188	815137	1060969
490313	641137	842979	1061863
494359	641652	845808	1064754
497953	642403	854732	1065695
510524	642911	854733	1070211
515072	646640	854734	1074703
515123	647469	854735	1076116
518799	647776	855371	1078521
520175	648240	866916	1082815
523947	650288	868199	1092997
529231	650513	874829	1094111
530509	651013	882795	1095315
536090	652319	893330	1102781
538214	652325	895064	1103621
540224	654041	898804	1108391
543455	656518	898805	1109634
543482	656779	899629	1109885
548190	656911	909118	1112379
548195	658246	912671	1131431
549105	659791	918311	1131540
549944	660551	919360	1131731
553058	662831	924214	1131732
558252	662832	924968	1151737
558426	662839	925219	1154372
565002	662842	927216	1159742
572201	662857	935905	1170087
573922	662859	938957	1171058
576356	662918	941005	1172441
579460	662919	941006	1173564
582206	669471	942060	1173647
585751	669272	942391	1182268
588929	670002	942392	1182541
590346	670057	950863	1190198
590641	670621	951835	1190330
591758	671336	952267	1195194
593127	674197	955911	1195875
596513	675758	957179	1205407
597429	690670	958548	1212982
598723	690982	961259	1217539
600502	691002	962117	1222524
600938	694731	963134	1224825
601131			

1234073	1284206	1374103	1435201
1247038	129674	1381652	1435202
1249700	1329901	1415850	1435202
1249982	1331455	1422740	1435203
1250769	1335848	1424016	1477452
1250770	1344404	1428948	1478792
1259393	1374101	1434076	2021264
1260223	1374102	1434305	2023817

15.2.3 U.S. Patent Specifications

1050153	2809528	3505883
1096253	2857122	3664748
1112997	2856142	4094200
1368226	3005185	4179087
2158180	3160927	4419832
2183312	3264883	4444053

Gyroscope Control

874255	2225014	2563983	2795956
898766	2252338	2567831	2800045
1030050	2274443	2571727	2801542
1031769	2290232	2574471	2802956
1134439	2293039	2581476	2808656
1150311	2303641	2585024	2810291
1163678	2303799	2585146	2813430
1183530	2315216	2586817	2814954
1279471	2315501	2588755	2816448
1342397	2325048	2589494	2817239
1407491	2341442	2590837	2817974
1456744	2342637	2595268	2822694
1485783	2349287	2600476	2827789
1499320	2349758	2602239	2852940
1545479	2351629	2603094	2855782
1557268	2357381	2607230	2856772
1558720	2369131	2610509	2856777
1590977	2383409	2618159	2857766
1610853	2383461	2620669	2864255
1610931	2397949	2638288	2865206
1613301	2410473	2643547	2868021
1617309	2414108	2662410	2868022
1618570	2415430	2667077	2874578
1625252	2415813	2669126	2879668
1628136	2416646	2672054	2879669
1642087	2417689	2682773	2893248
1650280	2419063	2685081	2894395
1655800	2424562	2687648	2899828
1730967	2443748	2688456	2903891
1778734	2444625	2695165	2906127
1822184	2451230	2700739	2909930
1880994	2457228	2704456	2912864
1885414	2459495	2704938	2916917
1997412	2468137	2707400	2916919
1999897	2468554	2707882	2926348
2007515	2478839	2709921	2926541
2015650	2483980	2711051	2933925
2048834	2484823	2713270	2934961
2104226	2494429	2714837	2937532
2137974	2504170	2728233	2937533
2152144	2504604	2729407	2940320
2167077	2512902	2734278	2943494
2180221	2524756	2735731	2945381
2191250	2527245	2737053	2947177
2199290	2530725	2746300	2948156
2200976	2553786	2752790	2951373
2209735	2555165	2787909	2953149
2217616	2559298	2790119	2964954
2219985	2561367	2795143	2968953

2968957	3131336	3277725	3486383
2969681	3135120	3277727	3498144
2981113	3142181	3279263	3555913
2985022	3142993	3280642	3604275
2986942	3147626	3282119	3613462
2986943	3176206	3283593	3619905
2986944	3187587	3285076	3633003
2987927	3188540	3285077	3702568
2988818	3205718	3301069	3704406
2993625	3209602	3301070	3704407
2998727	3214981	3304788	3709015
3000223	3221565	3315533	3762226
3001408	3229376	3318160	3794150
3002402	3229533	3319474	3805625
3010326	3231984	3320818	3815428
3014376	3234797	3320819	3875488
3018750	3237055	3323376	3883788
3033045	3238791	3323377	3898744
3046797	3238795	3323380	3938256
3051008	3240860	3324731	3941001
3052128	3241378	3324733	3967384
3053099	3251233	3336811	4003265
3058357	3251955	3353414	4005608
3068705	3252339	3363473	4026160
3073170	3253472	3365960	4036453
3077553	3256742	3368411	4078436
3077760	3257853	3398341	4111562
3080763	3260122	3413859	4125799
3082628	3267745	3424520	4155521
3082629	3269195	3426592	4189946
3082631	3269196	3430500	4189947
3085444	3273405	3449960	4214482
3089044	3274837	3453895	4274291
3094878	3276268	3456511	4275605
3107540	3276269	3463016	4277039
3126747	3276273	3469457	4285248

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15.3.1 Authors

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15.3.2 G.B. Patent Specifications

349026	611047	788486	938957
396547	654658	805535	957179
411124	691029	820887	958562
418377	733024	826417	985976
425111	748641	826418	1000515
444393	749987	826421	1040392
487299	751403	854506	1055334
494359	759609	890264	1111676
516567	762301	892969	1264113
541705	762346	902489	1343598
542529	764727	920678	
565802	772427	925576	

15.3.3 U.S. Patent Specifications

3158340
3187585
3664748
4212443

15.4 Helicopters V.T.O.L. Aircraft (use of gyroscope in)

15.4.1 Authors

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Sullivan N. (1963)

15.4.2 G.B. Patent Specifications

206506	682509	938186	1074703
272962	693729	951201	1092997
281736	698031	956536	1103901
292401	702080	965490	1177179
570404	730734	969269	1181668
576738	732149	975549	1202778
580231	854904	984986	1232243
597246	854905	998766	1329901
606420	854906	999007	1331455
632666	854907	1001363	1337035
635017	868199	1020185	1340293
635019	898203	1022711	1365430
670983	904570	1027011	2056063
675657	911082	1030238	
681382	927904	1044834	

15.4.3 U.S. Patent Specifications

3484172
3572965
4025230
4118143
4179087

15.5 Ejector Seat Control

15.5.1 Authors

No Entries

15.5.2 G.B. Patent Specification

1174464

15.6 Target Seekers

15.6.1 Authors

Manley C.J. (Editor) (1972)
Maxwell R.E. Jr. (1975)
McClendon J.R. (1982)
Nesline F.W. Zarchan P. (1983)
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15.6.2 G.B. Patent Specifications

133314	473000	777210	1015916
213791	600502	832480	1025740
227489	603448	958415	1031393
365731	624407	989069	1039612

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1051913	1301041	1428948	1543630
1116801	1320711	1446362	1539581
1136054	1326791	1446362	1543630
1161481	1351279	1475112	2015126
1269817	1351873	1493596	
1273161	1355326	1497065	

15.6.3 U.S. Patent Specifications

RE26887	3010677	3920200	4148026
1879187	3054342	3982174	4155521
2029664	3105657	4009393	4185797
2079559	3187588	4009848	4191346
2315216	3446082	4010365	4210804
2589484	3486026	4036453	4246801
2649262	3604277	4039246	4464943
2869803	3612643	4070678	4500051
2899677	3756538	4093154	4520973
2963973	3824865	4105174	4522355
3009152	3898668	4142695	

15.6.4 German Patent Specification

2522827

15.6.5 French Patent Specification

22381144

15.6.6 International Patent Specification

WO85/00055

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16.1 General

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16.2 Rockets

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1075705

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- Kachurina N.M. (1976)
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 Kennedy H.B. (1963)
 Khoroshilov V.S. (1984)
 Krementulo V.V. vii viii (1974) (1966)
 Kuo B.C. Sing G. Seltzer S.M. (1975) **
 Lange B.O. et al (1967)
 Liden S.P. (1974) **
 Leimanis E. (1965) (see pages 256-311)
 Likins P.W. Willems P.Y. (1971)
 Landon V.D. Stewart B. (1964)
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 Liu T.C. et al (1973)
 Lohfeld R.E. et al (1974)
 Longman R.W. Robertson R.E. (1969)
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 Margulies G. Aubrun J.N. (1978) **
 McGill D.J. Long L.S. (1975)
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 Popov V.I. (1971)
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 Roberson R.E. i ii iii iv v (1957-1968)
 Rubanovskii V.N. (1981)
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 Sarychev V.A. Mirer S.A. (1977)
 Scott E.D. Rubbe J.E. (1975)
 Seltzer S.M. (1975) **
 Shigehara M. Yasui S. (1969)
 Sierer W.H. Smyder W.A. (1969)
 Singer F. (1964)
 Singh S.N. (1983) (1976)
 Singh S.N. et al. (1975)
 Smol'nikov B.A. (1964)
 Sorokin A.V. (1979)
 Stepanov S. Ia. (1969)
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 Thomson W.T. Reiter G.S. (1960)
 Thome C.J. (1961)
 Tonkin S.W. Shackcloth W.J. (1978)
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 Vasil'ev V.N. Veinberg D.M. Sheremet'evsku N.N. (1978)
 Wong E.C. Lai J.Y. (1982)
 Yarber G.W. et al (1966) **

16.3.2 G.B. Patent Specifications

3318 f1915	1167997	1304867	1421275
1025740	1252141	1344256	1467559
1112763	1279098	1352981	1478792
1124129	1285919	1383425	1535174
1133605	1287341	1408504	1570529

16.3.3 U.S. Patent Specifications

2520929	3158340	3493194	3968352
2734384	3204467	3511452	4078748
2856142	3368411	3665281	4504033
2877667	3397851	3685770	4506853
3060425	3442468	3813067	

16.4 Momentum Wheels**16.4.1 Authors**

A.ekseev K.B. Zlodyeva O.V. (1985)
 Belyeava G.M. (1972)
 Cannon R.H.Jr. iii (1962)
 Krementulo V.V. (1966) (1968)
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 Smol'nikov B.A. (1964) (1966)

16.4.2 G.B. Patent Specifications

1133605
 1287341
 1304867
 1410219
 1478792
 1488951
 1511040
 1570529

16.4.3 U.S. Patent Specifications

3741500
 3968352
 4461436
 4608874

16.5 E.V.A. Boots**16.5.1 Authors**

Wrench E.H. Greensite A.L. (1970)

16.6 Green Cheese**16.6.1 Authors**

Fenster S.K. Peters W. (1962)
 Rosen B.M. (1959)

17. THE USE OF THE GYROSCOPE AND GYROSCOPIC FORCES IN VARIABLE GEARS, TRANSMISSION GEARING AND TORQUE CONVERTERS

17.1 Authors

No Entries

17.1.1 G.B. Patent Specifications

12361 of 1905	204062	344061	450360
6424 of 1911	221725	344062	455963
6428 of 1911	225518	344063	510518
22418 of 1911	225920	344064	595866
25621 of 1911	228563	344065	622337
21414 of 1912	238423	344066	637505
102514	256230	349101	667157
107251	259975	358732	675633
119511	261663	414693	695671
137205	276853	416032	744645
141027	304151	422577	1292613
141139	306307	435988	1421309
153538	328000	437950	
176326	343988	439627	

17.1.2 U.S. Patent Specifications

1544834	2223743	2960889	4152944
1728383	2223745	3153353	4152946 (See Reissue 30981)
1736789	2296654	3154971	4161889
1760850	2310724	3203644	4169391
1771806	2389826	3267770	4208926
1771807	2390341	3394619	Reissue 29328
1805612	2639631	3439561	4258581
1966357	2693723	3495479	4295381
1992457	2744422	3540308	4369673
2052507	2811050	3851545	4641550
2088834	2877667	3955432	

Classified by the U.S. Office as relating to Gyroscopic transmissions

1127251	1746544	1914813	2232234
1162593	1746545	1939100	2236639
1197309	1748108	1949042	2240649
1260943	1748110	1974103	2248444
1263701	1759466	1978416	2252815
1298506	1760700	1983641	2255566
1303287	1764266	1992457	2275725
1309257	1767311	1999340	2292638
1315380	1791386	2005974	2314278
1330393	1798723	2011755	2366637
1332708	1809123	2012652	2389826
1335168	1810282	2033474	2390341
1335169	1810283	2033475	2408228
1350106	1816615	2044172	2443038
1360216	1816808	2070621	2469646
1379941	1828825	2087060	2577667
1423458	1834689	2088034	2585**6
1525269	1847576	2093292	2635325
1572223	1858696	2100565	2645130
1609857	1860303	2118430	2678155
1622217	1861418	2122274	2700542
1630105	1865559	2142421	2886976
1688785	1867590	2167276	2924076
1693213	1874658	2177212	2960889
1705061	1878727	2178657	2980326
1718073	1881234	2211464	3148551
1725001	1885553	2218671	3181377
1730165	1897506	2225690	2289486
1745953	1914067	2231832	3293928

3339425	3965759	4169391
3407671	4019396	4179943
3581584	4034246	4254668
3863510	4050317	4335870
3955428	4141256	4641550
3955429	4161889	

17.1.3 *Australian Patent Specification*

488057

17.1.4 *Italian Patent Specification*

335495

8. THE USE OF THE GYROSCOPE AND GYROSCOPIC FORCES IN OPTICAL AND RELATED DEVICES

18.1 General

18.1.1 Authors

Arnold R.N. Maunders L. (1961)
Pontèves de D & Rafat R. (1972)

18.2 Telescopes, including Binoculars and Monoculars

18.2.1 Authors

Babayev A.A. Grishmanova N.I. (1968)
Babayev A.A. Sukhoparov S.A. (1972)
Bogdanov A.D. (1977)
Brake D.G. (1980)
Dienstbach C. (1915)
O'Dell C.R. (1973)
Ostrovskaya M.A. (1972)
Seitzer S.M. (1975)
Schiehlen W. (1974)

18.2.2 G.B. Patent Specifications

24112-1909	178459	844964	1150700
17291-1910	226163	958415	1235175
9737-1911	232759	1015916	1235707
10440-1911	282078	1056527	1269817
23494-1911	284871	1056528	1340212
24647-1914	353137	1093131	1399121
6977-1915	359895	1099026	1442773
146477	382253	1114094	1594060
146847	623009	1149164	2036998
165028	749988	1150699	2149259 (See EP 0141565)

18.2.3 U.S. Patent Specifications

940329	2811342	3468595	3756686
1050153	2829557	3471931	3756687
1363861	2871707	3473861	3762795
1628776	2939363	3475074	3881803
1628777	2959088	3503318	4013339
2570130	3158676	3531176	4270044
2684007	3200250	355632	4260218
2688456	3212420	3564931	4643539
2741940	3378326	3608995	
2779231	3437396	3608997	
2780140	3437397	3742770	

18.2.4 French Patent Specifications

1372585
1435872
1453827
1455923

18.2.5 European Patent Specifications

EP 0001204
G. 41665

18.2.6 International Patent Specification

WO 85/00668

18.3 Gunsights

18.3.1 Authors

No Entries

18.3.2 G.B. Patent Specifications

2077-1909	359071	653610	1183898
9466-1909	387848	684667	1236807
30583-1909	453744	694850	1269817
17291-1910	464315	714670	1340212
20373-1910	480185	724896	1349722
30184-1910	498745	724897	1352349
5903-1912	574704	724898	1388082
6977-1915	576359	724900	1475112
16669-1915	577129	754530	1491117
147061	578958	815729	1512932
154932	581966	950207	1531871
156870	587951	1069266	1559218
177146	603389	1073446	
232759	606635	1114094	
306764	633666	1161481	

18.3.3 U.S. Patent Specifications

1031769	2270896	2684007	3558212
1363861	2412453	2795371	3762795
1628776	2467831	2850526	3871236
1688559	2527245	2859657	4105174
1935442	2559435	2914945	
1984874	2570298	3326619	
2229645	2583815	3471931	

18.3.4 German Patent Specifications

Offenlegungsschrift
1428733

18.3.5 French Patent Specification

1563217

18.4 Bombsights

18.4.1 Authors

No Entries

18.4.2 G.B. Patent Specifications

127877	551880	624555
186099	575958	665498
413338	579848	716599
449238	586273	804700
473000	624133	950634
490811	624354	1072926

18.4.3 U.S. Patent Specifications

940329	2162699	2467831	2955356
1402064	2350303	2495304	3033084
1645079	2571606	2583315	3427437
1783769	2428678	2609606	3880043
2125225	2432613	2859326	
2162693	2466528	2859555	

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18.4.4 German Patent Specification

360390

18.4.5 French Patent Specification

749767

18.5 Cameras

18.5.1 Authors

No Entries

18.5.2 G.B. Patent Specifications

10757-1906	275649	1056528	1163017
5977-1915	402890	1099026	1235707
127877	578958	1142977	1235175
150995	590682	1145795	1450027
200098	650826	1149068	1499928
219082	808829	1151559	
223610	892453	1159770	

18.5.3 U.S. Patent Specifications

1586071	2951377	3468595
1645079	3409350	3473861
1688559	3424521	3475073
1709314	3424522	3479108
2180017	3424523	
2709922	3459473	

Gyroscope Aerial Camera Combined

85247	1585484	2346079	2792767
359902	1586070	2358777	2796009
367610	1586071	2371592	2796815
510759	1598082	2393575	2817278
578980	1612860	2397031	2839974
757825	1626787	2401530	2841063
863035	1661364	2409597	2895392
894348	1679354	2410842	2895393
935760	1735109	2413349	2899882
1002697	1764066	2415563	2906181
1200819	1782860	2424989	2929305
1212884	1782864	2429051	2937385
1221902	1797849	2468781	2949830
1300716	1821492	2472823	2950663
1301873	1824085	2474323	2955518
1301967	1826299	2476677	2961933
1305841	1829142	2506095	2963949
1309798	1848693	2507459	2967470
1313564	1863573	2512486	2969005
1372746	1880960	2521153	2995995
1382486	1898179	2544686	2998762
1413187	1939172	2570653	3000284
1423364	1942161	2544686	3007383
1469569	1953304	2570653	3060824
1482244	1955770	2575020	3066589
1490239	1974842	2596222	3094054
1502173	1986261	2599517	3114306
1517550	2014188	2622495	3121377
1528933	2047070	2671388	3143048
1531593	2198920	2685238	3143049
1536335	2240731	2713814	3158079
1546372	2283788	2719470	3160082
1548723	2307646	2766667	3163098
1559688	2333768	2766668	3212420

3215053	3338147	3491668	3653307
3217623	3352223	3495517	3662661
3221625	3364830	3500733	3667360
3234865	3392645	3511150	3687035
3234866	3410189	3511151	3688666
3240138	3422739	3532039	3703133
3240139	3435743	353341	3715962
3242836	3439599	3537369	3728948
3251283	3455221	3541936	3739699
3253525	3469515	3554105	3744387
3269290	3483808	3580150	
3303767	3485151	3608463	

18.5.4 German Patent Specification

2731134

18.5.5 Belgian Patent Specification

851740

18.6 Panoramic Sextants

18.6.1 Authors

No Entries

18.6.2 G.B. Patent Specifications

No Entries

18.6.3 U.S. Patent Specifications

2220884

2266741

2505819

18.7 Panoramic Film Viewer

18.7.1 Authors

No Entries

18.7.2 G.B. Patent Specifications

1010615

1307548

1317772

18.7.3 U.S. Patent Specifications

705771

888236

2515200

3218900

18.8 Periscopes

18.8.1 Authors

No Entries

18.8.2 G.B. Patent Specifications

5990 of 1901

10373 of 1901

226163

637358

1240552

118

18.8.3 U.S. Patent Specifications

2986966
3035477
3558212

18.9 Navigational Aids

18.9.1 Authors

No Entries

18.9.2 G.B. Patent Specifications

27508 of 1907	749989
284882	805535
286514	
749987	
749988	

18.10 Rangefinders

18.10.1 Authors

No Entries

18.10.2 G.B. Patent Specification

162677

18.11 Stabilisation of Image (Missiles etc)

8.11.1 Authors

No Entries

18.11.2 G.B. Patent Specifications

750889	1136054
1015916	1520845
1056527	
1056528	
1073446	

Directed to Optical Apparatus Stabilizing of part of Optical Systems etc.

1482-1906	650826	1159770	1349722
3683-1915	892453	1160528	1374766
6977-1915	1015916	1161481	1388082
16669-1915	1056527	1163017	1399121
155053	1056528	1168261	1442825
156870	1069266	1183898	1450027
162667	1073446	1235175	1475112
265028	1093131	1235707	1491117
226163	1099026	1236807	1491953
249616	1114094	1240552	1512932
262188	1136054	1269817	1520845
285457	1142977	1297729	1531871
387848	1145795	1307548	1539581
402890	1145068	1317772	1543630
449238	1149164	1320711	1559218
539342	1150699	1337034	
578958	1150700	1339379	
590496	1151559	1349212	

18.11.3 U.S. Patent Specifications

2869803
3293360
3371161
4606239

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19. INSTRUMENTS AND MACHINES THAT MAKE USE OF THE GYROSCOPE AND OR GYROSCOPIC FORCES

19.1 General

19.1.1 Authors

Arnold R.N. Maunder L. (1961)
Bogdanovitch M.M. ii (1961)
Grammel R. ii (1950)
Kudrevich B.I. (1965)
Magnus K. (1971)

19.2 Engine Governors

19.2.1 Authors

Maxwell J.C. (1868)
Siemens C.W. (1866)

19.2.2 G.B. Patent Specifications

17006 of 1905
18101 of 1913

19.2.3 U.S. Patent Specifications

220867 of 1879
785587 of 1905
1653660
1678914
1746794
3276572

19.3 Grinding Machines

19.3.1 Authors

Arnold R.N. Maunder L. (1961) p.171 etseq.
Ferry E.S. (1932) (worked example p.92-94)
Grammel R. i (1917)
Magnus K. (1971) p.98
Scarborough J.B. (1958) p.106-107

19.3.2 G.B. Patent Specifications

1437 of 1855	4117 of 1889	1860 of 1903	102631
2159 of 1857	7407 of 1890	11186 of 1904	166471
3704 of 1881	9809 of 1890	17735 of 1904	189120
13162 of 1886	20228 of 1891	24436 of 1912	247756
1162 of 1888	19824 of 1894	6193 of 1914	1336119

19.4 Speedometers

19.4.1 Authors

Aleksandrov A.G. et al (1975)

19.4.2 G.B. Patent Specifications

17006 of 1905	148247	596666
7285 of 1910	167503	616965
20515 of 1912	474718	874563
15812 of 1913	498112	939622
11827 of 1915	541705	1426236

19.5 Flowmeters

19.5.1 Authors

Akeley L.T. et al (1958)

19.5.2 G.B. Patent Specifications

498112	964446
717897	964447
893830	1003425
945387	1121117
953585	2015737
953586	2043902

19.5.3 U.S. Patent Specifications

720188	2602330	3000223
2106194	2625198	3187585
2406845	2714310	3312512
2450320	2865201	3485098
2472609	2914945	4187721
2585693	2969954	

19.6 Surveying Instruments (Clinometers, Theodolites, Borehole orientation)

19.6.1 Authors

Anon (1968)
 Astrakova N.P. (1972)
 Banks H.F. (1950)
 Ellms S.R. Huddle J.R. (1976)
 Ferranti Ltd (1976)
 Hassan A.K. (1983) *
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 Rellensman O. Pfeider E.P. (1959)
 Pavlov V.V. (1961)
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 Hamilton G.B. Amecn Y.K. (1977)
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 Stripling W.W. Hargleroad J.S. (1978)
 Trayner B.T. (1977)
 Williams H.S. (1969)

19.6.2 G.B. Patent Specifications

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163 of 1908	682908	1224992	1554204
3068 of 1908	885946	1227130	1554205
2077 of 1909	885947	1259753	1555286
30583 of 1909	886063	1278794	2009418
27005 of 1912	921562	1284429	2009419
18099 of 1913	941533	1306781	2027904
21905 of 1914	947322	1345848	2036311
120942	1008282	1373067	2039371
146372	1014352	1379642	2041519
289460	1016260	1382845	2075675
360523	1095817	1388311	2081910
558616	1100524	1428908	2094472
560200	1101956	1437125	2103793
563321	1132948	1509293	2104217
571622	1175863	1516074	2104224

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2111216	2139350
2124371	2064116
2126721	2141868
2126722	2146118
2124372	

19.6.3 U.S. Patent Specifications

1812994	3748912	4197654	4266431
2930240	4033045	4297790	4503718
3001290	4071959	4442723	4504857
3172213	4109391	4443952	4594790
3252339	4192077	4461089	4635375

19.6.4 German Patent Specifications

1798468
1941808
2459113
2734319
2734320
2756219

19.6.5 French Patent Specifications

2241686
2309835

19.6.6 Russian Patent Specifications

550852
579544
676866

19.6.7 European Patent Specification

EP 0077491

19.7 Percussion Fuses

19.7.1 Authors

No Entries

19.7.2 G.B. Patent Specifications

129036
400612
467712
920713
920714

19.8 Self-levelling Devices

19.8.1 Authors

No Entries

19.8.2 G.B. Patent Specifications

1580 of 1870
20985 of 1913
587951
612832
846879

19.9 Dynamometer Car

19.9.1 Authors

Amisler A.J. & Co. (1934)

19.9.2 G.B. Patent Specifications

284505
578784
675553
1324073
1468625

19.9.3 U.S. Patent Specifications

1843959
1906719

19.9.4 German Patent Specification

2055794

19.10 Gunsight Fire Control

19.10.1 Authors

Berkowitz B. et al (1968)
Brockner C.E. Price R.C. (1959)
Rees M. (1946)

19.10.2 G.B. Patent Specifications

223 of 1871	400685	653610	1183898
16687 of 1910	418670	657669	1223214
17291 of 1910	422234	675725	1236807
3663 of 1915	447225	684667	1261438
122199	455207	694850	1269817
146477	455431	700315	1285722*
146488	541224	714670	1301041
146847	590581	720079	1307548
155030	590682	720080	1311043
177146	590683	754530	1337035
177147	597188	758733	1339379
212934	601402	839031	1340212
214995	603389	839033	1349722
216156	616517	875754	1388082
262188	617237*	900047	1428948
374058	621836	930207	1486537
374059	625822	1069266	
382253	638714	1108072	

19.10.3 U.S. Patent Specifications

1238503	1936442	2229645	2504170
1452484	1937336	2270876	3009152
1628776	1939517	2293039	3629196
1688361	1984874	2383409	
1783769	2125225	2467831	
1855093	2162698	2423831	

*extensive mathematical dissertation

19.11 Weighing Devices (Dynamometer Cell)*19.11.1 Authors*

Anon (1982)
 Grämme R. li (1950) (Vol.2 see p.190)
 Graveney M.J. Sinha P.K. (1982)
 Wohwa J. (1984)

19.11.2 G.B. Patent Specifications

1468625
 1531503
 2015737
 2043902
 2070784
 2124373
 2124790

19.11.3 U.S. Patent Specifications

4095463
 4497213
 4577519

19.11.4 German Patent Specifications

2055794
 2119546
 2235808
 2434485
 3223403

19.11.5 French Patent Specification

2338485

19.12 Machine Tools*19.12.1 Authors*

Magnus K. vi (1974)
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843475*
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19.14 Skiing

19.14.1 Authors

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19.15 Drag-lines

19.15.1 Authors

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19.16 Profilograph (Road roughness)

19.16.1 Authors

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19.16.2 G.B. Patent Specifications

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19.16.3 U.S. Patent Specifications

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4561188

19.16.4 Russian Patent Specification

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19.17 Ball Bearings

19.17.1 Authors

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19.18 Velocipedes

19.18.1 Authors

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19.18.2 G.B. Patent Specifications

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19.18.3 U.S. Patent Specifications

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19.19.1 Authors

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19.20.1 Authors

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19.20.2 G.B. Patent Specifications

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19.20.3 U.S. Patent Specification

2716893

19.20.4 Russian Patent Specification

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19.21 Vehicle Side-slip

19.21.1 Authors

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19.21.4 Russian Patent Specification

478186

19.22 Chronometric Devices

19.22.1 Authors

No Entries

19.22.2 G.B. Patent Specification

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19.22.3 U.S. Patent Specification

2390341

19.23 Gyrostatically Actuated Relays*19.23.1 Authors*

No Entries

19.23.2 G.B. Patent Specification

116454

19.24 Gyroscopic Viscometer*19.24.1 Authors*

No Entries

19.24.2 G.B. Patent Specifications

No Entries

19.24.3 U.S. Patent Specifications

No Entries

19.24.4 Russian Patent Specifications

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525871

535481

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No Entries

19.25.2 G.B. Patent Specifications

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1553488

1599082

19.25.3 U.S. Patent Specifications

No Entries

19.25.4 Russian Patent Specifications

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625114

570843

634103

593152

634212

617723

620897

19.26 Dynamic Inductive Tap*19.26.1 Authors*

No Entries

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19.26.2 *G.B. Patent Specification*

888898

19.27 **Lateral Attitude of 4-wheel Car**

19.27.1 *Authors*

No Entries

19.27.2 *G.B. Patent Specifications*

990933

1246688

1360544

19.28 **Angular Deflection of Tall Buildings**

19.28.1 *Authors*

No Entries

19.28.2 *G.B. Patent Specification*

1132851

19.29 **Character of Marine Swell**

19.29.1 *Authors*

No Entries

19.29.2 *G.B. Patent Specification*

1215440

19.30 **Vehicle Anti-high-jack System**

19.30.1 *Authors*

No Entries

19.30.2 *G.B. Patent Specification*

1339820

(See U.S. 1843959)

19.31 **Motor-cycle Headlight Orientation**

19.31.1 *Authors*

No Entries

19.31.2 *G.B. Patent Specifications*

1470715

1538069

19.32 **Gyroscopic Engine**

19.32.1 *Authors*

No Entries

19.32.2 *G.B. Patent Specifications*

No Entries

19.32.3 *U.S. Patent Specifications*

1260943

2211064

19.33 *Clutch Mechanism*

19.33.1 *Authors*

No Entries

19.33.2 *G.B. Patent Specification*

675633

19.34 *Anti-hunting Regulator*

19.34.1 *Authors*

No Entries

19.34.2 *G.B. Patent Specifications*

No Entries

19.34.3 *U.S. Patent Specification*

2162482

19.35 *Travelling Cradle (toy)*

19.35.1 *Authors*

No Entries

19.35.2 *G.B. Patent Specification*

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19.35.3 *U.S. Patent Specifications*

1772208

2371368

19.36 *Gyro-bus*

19.36.1 *Authors*

Arnold R.N. Maunder L. (1961) (See p.162)

19.37 *Magnetic Switch*

19.37.1 *Authors*

No Entries

19.37.2 *G.B. Patent Specifications*

No Entries

19.37.3 *U.S. Patent Specification*

3307413

19.38 *Gyro-seismometer (See 19.44)*

19.38.1 *Authors*

No Entries

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19.38.2 *G.B. Patent Specifications*

No Entries

19.38.3 *U.S. Patent Specification*

4026383

19.38.4 *Russian Patent Specification*

490056

19.39 Windmills

19.39.1 *Authors*

Weisbrich A.L. (1978)

19.39.2 *G.B. Patent Specifications*

No Entries

19.39.3 *U.S. Patent Specification*

4302152*

19.40 Shaft Encoders

19.40.1 *Authors*

No Entries

19.40.2 *G.B. Patent Specifications*

No Entries

19.40.3 *U.S. Patent Specification*

3998088

19.41 Gyroscopic Aiming

19.41.1 *Authors*

No Entries

19.41.2 *G.B. Patent Specifications*

No Entries

19.41.3 *U.S. Patent Specification*

4218827

19.42 Gyro Extraction of Energy

19.42.1 *Authors*

No Entries

19.42.2 *G.B. Patent Specifications*

No Entries

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19.42.3 U.S. Patent Specification

2716893

19.42.4 French Patent Specification

2330881

19.43 Wave Energy (Ocean Wave Energy Conversion)

19.43.1 Authors

No Entries

19.43.2 G.B. Patent Specification

2058938

19.43.3 U.S. Patent Specification

4161889

19.44 Torque Generators Gyroscopic Vibrators (Seismometers) (See 19.38)

19.44.1 Authors

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Sorg M. (1968)

19.44.2 G.B. Patent Specifications

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1511040

19.44.3 U.S. Patent Specifications

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2716893

3691853

4026383

19.44.4 Russian Patent Specification

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19.45 Railway Car Roll Control

19.45.1 Authors

Santanera O. et al (1972)

19.45.2 G.B. Patent Specifications

No Entries

19.45.3 U.S. Patent Specifications

3683818

3789769

3844225

4267736

19.46 Measurement of Sliding Friction

19.46.1 Authors

No Entries

132

19.46.2 *G.B. Patent Specifications*

No Entries

19.46.3 *U.S. Patent Specification*

4498329

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21.1.1 Authors

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21.1.2 G.B. Patent Specifications

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 148458

21.1.3 U.S. Patent Specifications

3250137
 3576134*

21.2 Ship Anti-roll Devices

21.2.1 Authors

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19886 of 1890	582 of 1914	160192	349733
6943 of 1903	940 of 1914	162604	368281
1643 of 1906	6474 of 1915	194788	368724
17156 of 1907	8760 of 1915	197680	373832
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**history and mathematical dissertation

428533	564722	820431	1170596
430866	581776	821748	1240052**
439630	585751	829821	1381436
447259	635192	829822	1383348
458747	647930	957062	1413745
536031	670983	989751	
549843	719925	1070211	

21.2.3 U.S. Patents Specifications

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1232619	1610853
1236993	1800365
1312085	3279263
1318302	3576134
1452482	

Gyrostabilized furniture for ships

432070	622956	1101676
539953	701156	1323424
575005	926111	1416070
583155	941428	1846293
611833	1039185	

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21.3.1 Authors

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105753	731561	979580	1230846
127055	741960	986318*	1260617
128236	749987*	988089*	1263424
205535	749988	994465	1275880
262188	762301	994396	1278864
282633	762346	1009506	1297429
290203	763750	1015943	1299822
309150	777245	1023554	1318872
337828	777818	1028122	1319398
360259	790637	1034314	1337053
425034	791556	1040004*	1343598
427511	797929	1040392	1344404
444827	810440	1050530	1349229
451337	820486*	1051905	1353285
581891	826418	1054032	1358258
582329	826419	1055338	1375147
584451	826420	1064219	1388082
605955	833400	1071371	1394663
610029	839024	1075277	1421275
611005	854393	1078356	1424016
611008	854506	1078357	1431432
611009	856685*	1079310	1467559
611015	863456	1086178	1484793
611016	863457	1092162	1499928
611017	863458	1093549	1514780
611018	865344	1093550	1521638
611019	873128	1097682	2056063
611020	876424	1101934	2082801
611023	881722	1102813	2084727
611046	884061	1109615	2107865
612832	890489	1111456	2137445
622500	895999	1113642	2160647
643749	897756	1115832	2176004

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1050153	2320354	2667194	2936627
1112977	2405058	2696566	2942497
1253666	2409875	2729108	2944426
1446348	2414291	2740299	2955474
1501886	2469782	2752792	2960878
1548442	2517612	2762123	2969681
1589039	2533217	2771779	2970485
1735058	2542575	2809528	2971383
1930082	2591697	2835132	2577806
1947562	2595951	2845800	2566943
1972882	2598672	2855781	2990791
1999897	2603003	2898766	2995934
2008058	2606448	2900824	2999391
2200396	2613538	2928282	3000222

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3003356	3238794	3383926	3931747
3009361	3258795	3438268	4068538
3029646	3267745	3451275	4150579
3056303	3269194	3476129	4152942
3053099	3269195	3489018	4193308
312774	3272744	3527108	4258578
3140482	3275273	3616699	4275605
3164022	3280641	3648525	4442435
3188870	3285075	3747418	4472978
3214983	3293919	3811329	4520973
3230779	3306115	3818767	4573797
3232120	3327539	3871236	
3232122	3327540	3877316	
3238793	3368410	3918309	

21.4 Monorail Monocar Monocycle

21.4.1 Authors

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21843 of 1908	17399 of 1911	108695	1315119
12021 of 1909	22260 of 1911	127334	2101313
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21.4.3 U.S. Patent Specifications

991485	3145797
1236030	3250137
1513143	3277840
2415056	3373832
3124007	

Monorail Rolling Stock

175226	993104	1432655	2607300
176864	1019942	1437183	2976820
206722	1041680	1875248	2985114
208738	1042056	1947119	3012321
998193	1042067	1986845	3111912
453117	1043794	2178351	3319581
456293	1048679	2238569	3730103
684328	1064141	2346978	3881427
751960	1196402	2412598	
821863	1245480	2469042	
825958	1370526	2578267	

Monorail -Suspended

331389	1311018	1642562	3040678
376829	1314202	1743100	3055314
429847	1328163	1778332	3057305
433627	1355801	1801141	3072075
469460	1385754	1824291	3092039
538389	1392719	1828603	3092090
797769	1396507	1853570	3094979
812861	1401082	1864922	3134342
814933	1405079	1871907	3193140
855398	1405757	1991818	3224381
862896	1406987	2038824	3252429
885113	1411845	2265385	3324806
891875	1422255	2440019	3353503
911399	1429790	2532661	3361084
913642	1452303	2566962	3369501
919268	1460534	2567573	3556016
940768	1464011	2581948	3610166
976157	1469998	2855026	3759190
1151729	1522923	2927539	3802351
1217030	1530735	2943581	3855941
1219062	1546925	2949864	3902432
1237067	1551223	2968257	

21.5 Gun Stabilizers

21.5.1 Authors

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Hanna C.R. Lynn L.B. (1944)
Perry J. iii (1908)
Sputz J.P. (1962)
Rees M. (1946)

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13042 of 1909	146482	616602	657669
1174 of 1910	146488	621836	657670
15279 of 1912	147085	623009	657671
126028	590682	633474	720079
128236	593020	633866	720080
146478	611009	636117	722492
146480	616516*	650449	724896

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724878
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904570
1442822

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2509446
2586817

21.6 Small Instrument Stabilizers

21.6.1 Authors

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Dienstbach C. (1915)
Matthews R.J. (1980)
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21.6.2 G.B. Patent Specifications

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155053	560875	890264	1163017
200098	582257	901220	1168261
218415	611019	985976	1170596
219082	612239	1015916	1230846
223610	612832	1093131	1235175
275649	643410	1099026	1235707
284871	649703	1142977	1297729
315966	764727	1149164	1339379
373832	777245	1150699	1340212
382253	808829	1151559	2042724
456081	846879	1159770	

21.6.3 U.S. Patent Specifications

1050153	2603003	3742770
1112997	2734280	3784363
1324477	2811047	3871236
1650280	2845800	4026383
2432430	3313163	4180916

Gyrostabilized article support

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378430	1126720	3559937	4010923
439098	1150304	3712571	4034946
625392	1177165	3713612	4044982
671661	1186992	3740011	4083524
936769	3436050	3782671	4113215
1082053	3514592	3870265	4129280

21.6.4 Russian Patent Specification

469886

21.7 T.V. Image Stabilization

21.7.1 Authors

Duboury J. (1970)

21.7.2 G.B. Patent Specification

1539581

21.7.3 U.S. Patent Specification

4010365

21.8 Gyroscopic Absorber

21.8.1 Author

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22.1.1 Authors

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22.1.2 G.B. Patent Specifications

1108483
 1366500
 2061742

22.1.3 U.S. Patent Specifications

3531889
 3619942
 3956851

22.2 Diabolo

22.2.1 Authors

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22.2.2 G.B. Patent Specifications

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22.2.3 U.S. Patent Specification

3883985

22.3 Balancing Toys

22.3.1 Authors

No Entries

See Scientific American 104 (1911) p206

22.3.2 G.B. Patent Specifications

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29092 of 1911	193168	747054
2877 of 1912	409939	1068755
24528 of 1912	412112	1256545
16099 of 1913	479430	1303697
142402	512536	1340683

22.3.3 U.S. Patent Specifications

78745	188095	617665	829663
99644	484960	676191	889975
127619	514995	698286	918545
139988	609332	755446	919349

925479	1513143	2736132	3621603
929669	1555502	2747326	3628285
942952	1584579	2762162	3646703
944096	1627239	2991584	3674271
955465	1772208	3086316	3700239
975988	2038729	3137966	3726146
999247	2146374	3287846	3874663
1011202	2173031	3365835	3945146
1022236	2195083	3370377	4017083
1098895	2364117	3492758	4150580
1188488	2458851	3955429	4277912
1250266	2493834	3523386	4327518
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22.4.2 G.B. Patents Specifications

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22.4.3 U.S. Patent Specifications

966143

22.5 Manual Rotor and other Gyroscopic Exercising Systems

22.5.1 Authors

No Entries

22.5.2 G.B. Patent Specification

1333529

22.5.3 U.S. Patent Specifications

1075770
3617056
3726146
4150589

22.6 Bowling Ball

22.6.1 Authors

No Entries

22.6.2 G.B. Patent Specifications

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26401 of 1912

22.6.3 U.S. Patent Specifications

2078729
3617056
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4150580
4183527

144

22.7 Gyroscopic Golf Putter

22.7.1 Authors

No Entries

22.7.2 G.B. Patent Specifications

No Entries

22.7.3 U.S. Patent Specifications

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3270564	4017063
3333854	
3387844	

22.8 Spinning and Whirling Devices

22.8.1 Authors

No Entries

22.8.2 G.B. Patent Specifications

No Entries

22.8.3 U.S. Patent Specifications

Editor's Note:

In the original work, Mr. F.W. Cousins lists under this category some 2500 U.S. Patents. For the purpose of the AGARDograph it is only considered necessary to record their existence in total, rather than in detail.

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4026383

*Mathematical dissertation

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692608	1826905	2953378	3565434
906206	2324022	2972481	4103983
925445	2361988	3312472	4106770
107072	2683603	3303909	
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1181136	2158180	3540293	4450451
1316033	2805577	3824865	4467639
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607440	1156350	1402745	2754789
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716517	1179439	1418851	2974521
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814969	1197134	1431140	3067710
818987	1204852	1431141	3083666
839161	1233761	1431142	3332382
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24.5.1 Authors

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24.5.2 G.B. Patent Specifications

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784576	102476	1170596	1478792
793795	1031395	1180546	1486537
832480	1039695	1181685	1491953
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842775	1066914	1196401	1539581
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24.6.3 U.S. Patent Specifications

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2158180	3311326	3933096	4218827
2815584	3434354	4010365	4236414
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*Mathematical dissertation

25. INERTIAL DRIVES AND MACHINES GIVING UNI-DIRECTIONAL MOTION FROM ROTARY GYROSCOPIC MOTION (ANTI-GRAVITY)

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 Anti-gravity breakthrough

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1063784

25.1.6 *International Patent Specification*

WO86/05852

*See Laithwaite E.R. iii (1975)

**This invention was demonstrated to the German Patent office in Munich on 30 April 1974 and was supported by a Statutory Declaration in support of its motion by Prof. E.R. Laithwaite dated 2 October 1973. The same device was seen to work by Mr G.K.C. Pardoe of Hawker Siddeley Dynamics Ltd and this is stated in a letter to the inventor of 14 Nov 1972. A subsequent Technical Note TN 3928 of 5 March 1973 by Hawker Siddeley Dynamics written by A. Smith attempts to show that the machine cannot work from a mathematical analysis.

26. MATHEMATICAL ANALYSES AND THEORY

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26.3 A Review of the Mathematical Analyses listed previously

The mathematical investigations into the dynamics of an absolutely rigid body about a fixed point have been extensive, both in Europe and in the Soviet Union. In Europe we have the early work of Hess, W. (1896)* and that of the Russian mathematician Sofya Vasilyevna Kovalevskaya (1850-1891)**.

Kovalevskaya formulated the statement of the existence of unique solutions of the problem of the rotation of a heavy body about a fixed point. Her classic work is well explained by Tabor, M. (1984) who shows that it concerned the solution of the Euler-Poisson equations that describe the motion of a top spinning about a fixed point. They are a set of six, first-order, nonlinearly coupled, ordinary differential equations of the form

$$\begin{aligned} A \frac{dp}{dt} &= (B - C)qr - \beta z_0 + \gamma y_0 & \frac{d\alpha}{dt} &= \beta r - \gamma q \\ B \frac{dq}{dt} &= (C - A)pr - \gamma x_0 + \alpha z_0 & \frac{d\beta}{dt} &= \gamma p - \alpha r \\ C \frac{dr}{dt} &= (A - B)pq - \alpha y_0 + \beta x_0 & \frac{d\gamma}{dt} &= \alpha q - \beta p \end{aligned}$$

where (p, q, r) and (α, β, γ) are the components of angular velocity and the direction cosines (that define the orientation of the top) respectively. The variables (A, B, C) and (x_0, y_0, z_0) are the moments of inertia and the position coordinates of the centre-of-gravity respectively. These are the adjustable parameters of the system — for different values of which the system may or may not be integrable.

*See Stepanova, L.A. (i) *O. rabotakh D.N. Goriacheva po dinamiku tverdogo tela* Mekhanika Tverdogo Tela Kiev (1969) pp.65-75 (ii) *K. istorii resheniya V. Gessa zadachi o dvizhenii tela imelushchego dvizheniye tochiku. O nekotorykh obobshcheniyah invariantnogo* soobshcheniya Gessa Mekhanika Tverdogo Tela Kiev (1970) pp. 1-10.

**See Polubarinova-Kochina P. (1957); Elsgolts L. (1970) pp.211-250; Kramer E.F. (1973); Tabor M. (1984).

The solving, or integrating, of such a system of equations proceeds by identifying the integrals of the motion — a complex integration requires one to find as many integrals as the order of the system (six in this case). These integrals are various analytical functions of the dependent variables that are constant in time. From fundamental physical considerations there are certain classical integrals that can be identified immediately. These are the total energy, the angular momentum and, from simple geometric considerations, the sum $\alpha^2 + \beta^2 + \gamma^2$. As it turns out, with further standard simplifications, a complete solution of the problem requires the finding of only one more integral. The quest for this fourth integral became a popular problem in eighteenth and nineteenth century mathematics. However, it could only be found for three special cases: the trivial case of $A = B = C$, the case $x_0 = y_0 = z_0$ due to Euler and the case $A = B$, $x_0 = y_0 = 0$ due to Lagrange. A general solution to the problem, according to Tabor, seemed to be unobtainable.

The quest for the existence conditions of the fourth integral was finally solved *inter alia* by Poincaré J.H. c.1881. See Sergeev V.S. (1982). Poincaré P. (c.1891 to c.1900) Husson E. (1905) Burgatti P. (1906-1910) and Polubarinova-Kochina (1940). For a comprehensive work in English see Leimanis E. (1965).

Fradlig B.N. and Slyusarenko V.M. (1975)*, a translation of whose work is reproduced below, show that attempts have been made to obtain the equations that have the simplest form [17, 38, 39, 53, 86, 98, 103, 108]**. A result close to that expected had already been obtained by Weiss [21] in the 19th century. Introducing new variables, Hess indicated a third-order system, which, however, also contained leading variables. The Hess equations are discussed in the monographs of A. Gray and V.V. Golubev [2] and the articles under the following references [129, 135, 141, 144, 145, 146].

N. Kowalewski's problem of 1908 [134] reduced to two equations, each of which is of the second order, under the assumption that the centre of mass of the body is found on one of its principal axes of inertia with respect to a fixed point. Using these equations, he succeeded in obtaining a new solution. Similar equations are presented in the manuscripts of S.A. Chaplygin [72], where the first integral of these equations is indicated, and the integrability case bearing his name is obtained, generalizing the solution of Goryachev [33].

Using the usual methods of analytical dynamics, Bilimovich [17] and Kharlamova [88] showed that the problem can be reduced to a single second-order differential equation; however, the latter can prove to be extremely cumbersome.

Kharlamov [110] proposed a new approach to the solution of this question. He noted that in the investigation of the problem of the motion of a heavy rigid body in a number of cases it is more convenient to refer the motion of the body to coordinate axes that the author calls special. The dynamic equations of the problem obtained by Kharlamov [103, 108] in the special coordinate system have the form

$$\begin{aligned} & [(a_2 - a_1)yz + (b_2y - b_1z)x] \left(y \frac{dz}{dx} - z \frac{dy}{dx} \right) + (y^2 + z^2)(b_1y + b_2z) \\ & + x \left[\left(a - \frac{a_1}{2} \right) y^2 + \left(a - \frac{a_2}{2} \right) z^2 \right] + \frac{a}{2} x^3 - Ex - k = 0; \end{aligned} \quad (1.1)$$

$$\begin{aligned} & \left\{ [(a_2 - a_1)yz + (b_2y - b_1z)x] \frac{dy}{dx} + (a_2 - a)xz - (b_1y + b_2z)z + b_2x^2 \right\}^2 \\ & + \left\{ [(a_1 - a_2)yz + (b_1z - b_2y)x] \frac{dz}{dx} + (a_1 - a)xy - (b_1y + b_2z)y + b_1x^2 \right\}^2 \\ & + \left[\frac{1}{2}(ax^2 + a_1y^2 + a_2z^2) + (b_1y + b_2z)x - E \right]^2 - \Gamma^2 = 0. \end{aligned}$$

In these equations x , y , and z are the components of the angular momentum of a body in a rectangular special coordinate system, the first axis of which passes through the centre of mass of the body, and the remaining axes of which are chosen so that the kinetic energy of the body will be

$$T = \frac{1}{2}(ax^2 + a_1y^2 + a_2z^2) + (b_1y + b_2z)x.$$

Considering the problem of the motion of a heavy rigid body with a fixed point as a particular case of a more general problem — the problem of the motion of a heavy gyrostat with constant gyrostatic moment — Kharlamov [110] reduced the latter to the integration of a system of six ordinary differential equations,

*Soviet Applied Mechanics 11 No. 8 (1975) pp 809-819

**The numerals in square brackets refer to the bibliography at the end of this Review. The bibliography extends to 149 references, many in the translation published in 1975 are inaccurate and carry no pagination, further certain works are stated to be in Russian when in fact English translations exist. The bibliography in this section is fully corrected for readers of English.

$$A\ddot{\varphi} = (E - C)qr + \lambda_1 r - \lambda_2 q + (I_2 v_1 - I_3 v_2) \Gamma$$

$$v_i = r v_2 q v_3 (A, B, C, p, q, r, 1, 2, 3), \quad (1.2)$$

where λ_1 , λ_2 , and λ_3 are the components of the gyrostatic moment, constant with respect to the body.

This system of equations was transformed [108] to the form (1.1). Almost all the results of the classical problem of the motion of a heavy rigid body with a single fixed point were extended to the problem of the motion of a heavy gyrost.

In the most general form of Kharlamova [50], one of the three principal variables x , y , and z was eliminated in Equations (1.1). However, the established differential equation, which connects the two principal variables, is extremely cumbersome, and is therefore practically useless. Of principal value is the integrodifferential equation first found by Kharlamova [86], which is equivalent to the system of differential equations of motion of a heavy rigid body about a fixed point. This equation opened many possibilities for further investigations in the given area. The equation of Kharlamova was obtained assuming that in the principal plane of the ellipsoid of gyration for a fixed point, there lies the centre of mass of the system and the vector of the gyrostatic moment. It connects the two components x and y of the angular momentum with respect to the coordinate axes belonging to the indicated plane.

Solutions Obtained in the 20th Century for the Equations of Motion of a Heavy Gyrost.

We first distinguish the solution with three linear invariant relations, which was studied by Kharlamov [110, 112]. It determines the class of simplest motions of the body (uniform rotations of the body about a fixed point). A cone fixed in the body is indicated, and its generatrices can serve as axes of uniform rotation. This cone was thoroughly studied by Anchev [1, 2] and Kovalev [45], and in the absence of a gyrostatic moment it was investigated earlier by O. Shtaud and B.K. Mlodzeevskii. This question has also been studied by other authors [62, 69, 70, 121, 135, 139, 149].

There exists a unique solution with two linear invariant relations given by Kharlamov [104, 109, 110], which was obtained under the condition that the centre of mass of the gyrost lies in the principal plane of the inertia ellipsoid. The motion of the body so obtained is given a kinematic interpretation [107]. A particular case of the given solution is the Bobylev — Steklov solution (see the work of V.V. Golubev [21]) and the solution of the problem of the motion of a physical pendulum.

There are four well-known solutions with a single linear invariant relation; these are the solutions of Lagrange in 1738 (see Grioli [128], Sretenkii [73, 74], and Kharlamova [89]).

Sretenkii obtained the indicated solution by assuming that the centre of mass of the gyrost is perpendicular to the circular cross section of the ellipsoid of gyration. A particular case of this solution is the solution of Hess, which was studied earlier by P.A. Nekrasov, S.A. Chaplygin, N.E. Zhukovskii (Joukowski), G.G. Appell, and B.K. Mlodzeevskii. A complete review of these studies is given in the works of Stepanova [76, 77]. A geometrical interpretation of the solutions of L.N. Sretenkii and V. Hess was given by Kovalev [44, 45-50].

In 1947, Grioli [128] obtained a solution with a single linear invariant relation, describing the regular precession about an oblique axis. It was obtained and generalized by Kharlamova [89, 92]. In [92] the solution of Grioli was investigated on the basis of the kinematic equations of Kharlamov [110].

The question of the existence of solutions with linear invariant relations was first considered by S.A. Chaplygin, and the results were refined by Kharlamov [102]. These investigations were conducted under the condition that the centre of mass of the body lies in the principal plane of the ellipsoid of gyration, and that the gyrostatic moment equal zero. The investigation of the problem of the motion of a heavy rigid body about a fixed point with the help of the integrodifferential equation established by Kharlamova [86] allowed a complete solution to be obtained for the question of the conditions of existence for solutions with algebraic invariant relations under certain limiting assumptions: the centre of mass of the body lies in one of the principal planes of the ellipsoid of gyration, and the gyrostatic moment is not zero [91, 96]. In this case the new and most recent solution with a linear invariant relation is obtained [89]. Solutions [81, 83], found earlier by Kharlamova, are a particular case of this solution.

Goryachev indicated a solution [32] in which, in addition to a quadratic invariant relation, there is also a fourth-degree invariant relation. Kharlamov [110, 111] completely investigated this solution and gave a geometrical interpretation for the motion of the body. In studies [105, 110, 111] he indicated two more solutions. The first solution with two quadratic invariant relations was obtained under the condition that the centre of mass lies on one of the principal axes of inertia, and the vector of the gyrostatic moment is directed along this axis. The solution of Steklov [21] is a particular case of this solution. The second solution generalized the case of Kovalevskii [134]. The indicated solutions are discussed in the studies [28, 29, 61, 65, 67, 99, 116].

Chaplygin in 1948 [120] obtained a solution in which, besides a quadratic invariant relation, there is also a sixth-degree algebraic invariant relation. The geometrical interpretation of this motion was given by Kharlamov [110].

A solution with a quadratic invariant relation was obtained by A.I. Dokshevich under the condition that in a Lagrange gyroscope the gyrostatic moment is arbitrary. The uniqueness of this solution was shown by Kharlamova [94].

We note three more solutions with a quadratic invariant relation. These are the solutions of Kharlamov [114], Kharlamova [86, 95], and Kharlamova and Kharlamov [100]. Particular questions referring to the given solutions are discussed in the studies [40, 41, 51, 97, 101, 115, 117].

The algebraic invariant relations in four solutions — those of Strutsenskii [73, 74], Dokshevich [42], Mozalevskaya [62, 63], and Kononovich and Pozdnyakov [54] — contain terms of higher degree. Thus, in the solution of [62] there exist two third-degree algebraic invariant relations, and in the solution of [42] there exist two fourth-degree algebraic invariant relations. The solution of [54] is very special in structure. It was investigated in [55] using the hodograph method. The indicated solutions were obtained for very strict constraints imposed on the mass distribution and on the initial conditions.

Thus, in the problem of the motion of a heavy gyrost at there exist twenty solutions in closed form, of which three of them had been found in the 18th and 19th centuries (we bear in mind the solution of L. Euler, generalized by N.E. Zhukovskii (Joukowski), the solution of J. Lagrange and S.V. Kowalewski as discussed by L.V. Kudryashova and L.A. Stepanova in [58] and by G.N. Savin et al in [71]).

A review of the exact solutions of the dynamic equations of the problem being considered was given by Kudryashova and Stepanova [55].

Geometrical Interpretation of the Motion of a Rigid Body about a Fixed Point.

For a long time the general theorem of Poincaré about the interpretation of the motion of a body with a fixed point by means of the rolling without slipping of a moving axoid with respect to a fixed axoid was not used because the construction of a fixed axoid using the Euler angles is a very complicated problem; this is because in the transformation from a moving system to a fixed system in these parameters we obtain cumbersome and nonsymmetric expressions which hinder the investigation of the motion of the body. This impasse was overcome by Kharlamov [108, 110], who established new kinematic equations of the fixed hodograph of the angular velocity.

$$\omega_x = \omega_1 v_1 + \omega_2 v_2 + \omega_3 v_3; \quad \omega_p^2 = \omega_1^2 = \omega_2^2 + \omega_3^2 - \omega_x^2;$$

$$\omega_p^2 d\alpha = \begin{vmatrix} v_1 & v_2 & v_3 \\ \omega_1 & \omega_2 & \omega_3 \\ d\omega_1 & d\omega_2 & d\omega_3 \end{vmatrix}$$

(ω and v are functions of some time-dependent parameter σ).

Since it is the directrix of the axoid of the body, the hodograph of the angular velocity enables us to construct this cone and to reduce the investigation of the motion of a rigid body with a fixed point to the motion of the rolling of a moving axoid with respect to a fixed axoid. Using this method, a geometrical interpretation of the motion of a gyrost at in various cases of integrability is obtained in the studies [24, 26, 29-31, 46, 48-50, 51, 55, 61, 63-65, 87, 99, 110, 111, 116, 117].

Motion of a Rigid Body with a Fixed Point in a Potential Force Field.

First, we should note the studies of Goryachev [34-36], in which solutions are constructed for the problem of the motion of a body in a potential force field under the condition that the forces acting on the body admit a force function U . The question dealing with the search for the function U , in such a form that the equations of motion admit integrals of definite form, is solved. A detailed review of these solutions has been given by Stepanova [75].

In recent years, there has been increased interest in the problem of the motion of a rigid body in a Newtonian force field, formulated by L. Euler back in the 18th Century, in connection with investigations of the motions of artificial satellites. In calculations of the rotational motions of gyroscopes and satellites, the gravitational field almost always is assumed to be homogeneous. This assumption is inadmissible in more exact investigations in which the forces of Newtonian attraction must be taken into account.

Beletskii [12-14] has considered this problem under the assumption that a fixed point is found at a sufficiently large distance, in comparison with the dimensions of the body, from the centre of attraction. Under these conditions on the basis of the general theory of Goryachev [34], approximate equations of motion, which generalize the equations of the classical problem of the motion of a heavy rigid body about a fixed point, are derived. Beletskii has shown that the problem being considered is finally solved if the body has complete kinetic symmetry, and also in cases similar to the cases of Euler and Lagrange. He has reduced the problem to quadratures and given its complete solution for the case of plane motion. In [13-15] he has considered the indicated problem for the case in which the force field is symmetric with respect to some axis.

A series of studies by Arkhangel'skii [6-10] referring to the indicated problem are devoted to the determination of the conditions for existence of a fourth algebraic integral and the construction of solutions in which the principal parameters are single-valued functions of the complex variable t . In these studies it is shown that the solutions of the equations of motion of the body are single-valued functions of time only if the body is fixed at the centre of mass or has dynamic symmetry about one of the principal axes of inertia, and the centre of mass of the body lies on this axis.

Important results in the development of the given problem have been obtained by Kharlamova and Kozalova [98], who constructed dynamic equations of the problem of the motion in a Newtonian force field of a system of rigid bodies having the structure of a gyrost at:

$$\begin{aligned}
& A_1 \omega_1 + (A_1 - A_2) \omega_2 \omega_3 + \lambda_3 \omega_3 = (I_1 v_3 - I_3 v_2) \Gamma + \\
& + \varepsilon^2 A_{23}^* v_2 + A_{12}^* v_1 + A_{33}^* v_3 - (A_{23}^* v_1 + A_{22}^* v_2 + A_{21}^* v_3) v_3, \\
& v_i = \omega_i v_2 - \omega_2 v_3 \quad (i, 2, 3).
\end{aligned} \quad (2.1)$$

For the conditions in which the tensors \bar{A} and \bar{A}^* that arise in the calculation of the angular momentum and the moment of the Newtonian force field coincide and the hydrostatic moment equals zero, these equations are simplified:

$$A_1 \omega_1 = (A_1 - A_2)(\omega_2 \omega_3 - \varepsilon^2 v_2 v_3) + (I_1 v_3 - I_3 v_2) \Gamma, \quad v_i = \omega_i v_2 - \omega_2 v_3 \quad (i, 2, 3).$$

For the conditions in which the tensors \bar{A} and \bar{A}^* coincide, Kharlamova [85] obtained exact solutions of system (2.1), similar to the case of Lagrange integrability and the problem of the motion of a physical pendulum. She determined a new case of integrability for the conditions

$$I_1 = 0, \lambda_1 = 0, A = B + C, (B^2 \lambda_2^2 + C^2 \lambda_3^2) \varepsilon^2 = (B^2 \lambda_2^2 + C^2 \lambda_3^2) \Gamma.$$

Kovaleva [52] solved the question of the conditions of existence of the solutions of system (2.1) with linear invariant relations.

In the case of the establishment of definite constraints on the parameters of the system in the solution of Kharlamova [85], Gorr [22, 23, 25, 27] investigated moving and fixed hodographs of the angular velocity and gave a geometrical interpretation for the motion of the body.

Some of the studies of Kharlamova [82, 84] are devoted to the construction of exact solutions of system (2.2). A complete review of these investigations is given in the article by Kudryashova and Stepanova [57].

Motion of a Rigid Body about a Fixed Point in the Presence of Additional Constraints

The first experiment on the formulation of the problem of the rotation of a rigid body about a fixed point in the Euler case in the presence of nonholonomic coupling was conducted by Suslov [78], Voronets [19], and Vagner [18], who did not impose any constraints on the moments of inertia of the body, but assumed that the centre of mass of the body coincides with the fixed point.

Realization of the nonholonomic constraint $\omega_3 = 0$ Suslov is carried out such that the body is connected to a filament, which does not yield under torsion; the other end of the filament is rigidly fixed, where the tangent to the filament at the point at which the filament is fastened to the body passes through a fixed point O. Under this condition the instantaneous axis of rotation of the body is in a plane that is permanently coupled with the body, passing through the point O perpendicular to the indicated tangent.

Vagner proposed another realization of a nonholonomic constraint (a rigid body provided with two small wheels with sharp ribs lying in a single plane).

Recently, a number of studies [43, 66, 79, 80, 93, 115, 118] have appeared, which are devoted to the study of problems of the motion of a heavy rigid body with a fixed point in the presence of additional constraints.

The principal results in this direction were obtained in the studies of Kharlamov, Kharlamova née Zabelina, and Mozalevskaya [43, 61-67, 86, 93, 115, 118].

In 1957, Zabelina [43] investigated the indicated problem under the condition that the centre of mass of the body be found in the principal plane of the inertia ellipsoid with respect to its point of support, not coinciding with the fixed point of the body, and with account of the action of gravitational forces. The nonholonomic constraint in this investigation can be realized either based on the method of Suslov or the method of Vagner. The case of integrability is found by applying the theory of the reducing factor of Chaplygin, which he developed for an investigation of nonholonomic systems.

In the study of Kharlamova-Zabelina [80], a nonholonomic constraint is assumed to be realized such that the instantaneous axis of rotation of the body throughout the entire motion does not leave some specific plane permanently fixed in the body. Using a method proposed by Stretenskii, Kharlamova-Zabelina considers the case of rapid rotation of a body and presents a detailed investigation of the trajectory of the apex, which enables one to construct an explicit geometrical representation dealing with the motion of the body for the given nonholonomic constraint.

The problem of the rotation of a rigid body about a fixed point restrained by a nonholonomic constraint can be extended to the case of a heavy gyrostet. Such an extension was obtained by Kharlamov and Kovaleva [115]. The nonholonomic constraint here is accomplished as a result of pure rolling of a body-carrier having a fixed point and sharp circular ribs over a fixed surface of a hollow sphere inside of which the gyrostet is placed. Using the theorem of the variation of the kinetic moment, the author constructs dynamic equations of motion of the gyrostet to which the equation of nonholonomic constraint is added. These equations are easily solved in the simplest case of uniform rotation of a body-carrier.

The problem of the motion of a heavy gyrostat is investigated by Kharlamova [93] under the assumption that the centre of mass of the gyrostat coincides with the fixed point of the body-carrier. An exact solution is obtained and the moving hodograph of the angular velocity of the body is investigated. The case investigated by Vagnar [18] and earlier by Suslov [78] is a particular case of the indicated solution. In reference [118] a solution of this problem with an invariant relation that is linear with respect to ω_1 and ω_2 is given. This solution is a generalization of a number of known solutions of the indicated problem, found earlier by Bobylev and Steklov [21], and Kharlamova/Zabelina [43, 80]. As was determined by Mozafeyevskaya [66], the solution with a linear invariant relation that was found by Kharlamov and Kharlamova in [118] is the only solution of this kind.

A review of studies of the problem being considered in the presence of nonholonomic coupling is given in references [59 and 71].

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It is worth recording that Krylov was much respected in the West. See note below from a detailed article in English to be found in Prikladnaya Matematika i Mekhanika 10 No. 1 (1945) pp.5-7 (pages 8 to 20 give a complete bibliography of his works (in Russian) from 1885 to 1944)

Note:

Krylov investigated the general case of the motion of a ship when its course lies at any given angle to the direction of the waves, and summed up his conclusions in a paper entitled "General Theory of the Oscillations of a Ship on Waves", which was also published in English and French. Here he followed the same path he had outlined in his previous work, making all the necessary changes in setting up the differential equations of the motion of the body of the ship, whose position now had to be defined by all six parameters (three coordinates of the centre of gravity and three Euler angles). This led to increasing the number of equations to be integrated. The new problem did not raise any particularly difficult new questions, and in his work "On Stresses Experienced by a Ship in a Seaway", published by the Institute of Naval Architects in London, Krylov presents a computation of the strains set up in a ship in this more complicated case. These classic works placed Krylov in the first rank of world authorities on the theory of ships. The Society of English Shipbuilding Engineers awarded him the gold medal of the

Society, an honour bestowed on no foreigner before him. Such works as those mentioned above and his work in the theory of rolling stabilizers, Schlick gyroscopic stabilizers and Fram cisterns won recognition everywhere. Krylov was entrusted with writing the chapter on the theory of ships in the great encyclopedia of mathematical sciences, begun prior to World War I under the supervision of the famous mathematician Klein. The compilers of the encyclopedia set themselves the task, as Bo'tsman said, of finding the leading specialists in each field to draw up the various articles. Krylov's works are studied all over the world and are a guide to shipbuilding. In 1942 he was elected an honorary member of the Society of English Shipbuilding Engineers.

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Prikladnaya Matematika i Mekhanika 10 (1946) pp.101-124
*This important paper is referred to by RIVKIN, S.S. It is not translated into
English, as far as I am aware, but a note in English appears at the end of the
Russian work. English translation of the Russian title of a work in Russian

Recent years have seen the ever-greater application of multi-gyroscopic systems in instruments designed to maintain horizontal planes of moving ships. The value of the employment of such systems was pointed out in the work by Krylov entitled General theory of gyroscopes and some technical applications of them. Krylov points out (page 265) that stabilization of platforms on a ship may be attained by the following means: the platform is suspended within a knuckle joint being attached to its internal ring. Attached to the platform are two gyroscopic stabilizers, one of which nullifies roll, the other pitch. The present paper is devoted to an investigation of the above outlined idea. In paragraph 1, the author gives a brief description of multi-gyroscopic verticals. Paragraph 2 gives differential equations for the motion of the instrument. Paragraph 3 discusses the motion of the instrument on a fixed support. Paragraphs 4 and 5 take up the influence of rolling and acceleration of the moving ship. Here it is established that the data yielded by a multi-gyroscopic vertical are much more precise in rolling than the data yielded by a single gyroscope. Paragraph 6 studies the motion of a multi-gyroscopic vertical with a free oscillation period equal to the period pointed out by M. Schuler $T = 84.4$ minutes. Paragraph 7 is devoted to the increase of error in gyro-verticals for extended manoeuvring of the ship. The 9th and last paragraph discusses ballistic deviation of multi-gyroscope verticals with a small free oscillation period. The author's gratitude is due to the B.V. Bulgakov, whose methods were used throughout in the present work and who gave the author much valuable advice.

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REPORT DOCUMENTATION PAGE			
1. Recipient's Reference	2. Originator's Reference	3. Further Reference	4. Security Classification of Document
	AGARD-AG-313	ISBN 92-835-0441-0	UNCLASSIFIED
5. Originator	Advisory Group for Aerospace Research and Development North Atlantic Treaty Organization 7 rue Ancelle, 92200 Neuilly sur Seine, France		
6. Title	THE ANATOMY OF THE GYROSCOPE (A Report in Three Parts Comprising a Literature and Patent Survey Directed to the Gyroscope and its Applications)		
7. Presented at			
8. Author(s)/Editor(s)	Frank W. Cousins, edited by John L. Hollington		9. Date
			February 1988
10. Author's/Editor's Address	Various		11. Pages
			296
12. Distribution Statement	This document is distributed in accordance with AGARD policies and regulations, which are outlined on the Outside Back Covers of all AGARD publications.		
13. Keywords/Descriptors	<p>Gyroscope, Navigation, Stabilisation,</p> <p>Coriolis effects, Gyroscopic forces, Tops, and NATO FRENCH, (RIH)</p>		
14. Abstract	<p>This report on the gyroscope and its applications collates the technical information to be found in the patent literature, augmented by that residing in the text books and technical journals. The report is in three parts; Part I is a patent survey arranged in a detailed classification, Part II comprises a bibliography of the references in Part I and Part III, published as a separate volume, gives historical notes and comments on the material of Parts I & II.</p> <p>This AGARDograph has been prepared and edited at the request of the Guidance and Control Panel of AGARD.</p> <p><i>Keywords include:</i></p>		

<p>AGARDograph No.313 Advisory Group for Aerospace Research and Development, NATO</p> <p>THE ANATOMY OF THE GYROSCOPE (A Report in Three Parts Comprising a Literature and Patent Survey Directed to the Gyroscopic and its Applications) by Frank W.Cousins, edited by John L.Hollington Published February 1988 296 pages</p> <p>This report on the gyroscope and its applications collates the technical information to be found in the patent literature, augmented by that residing in the text books and technical journals. The report is in three parts; Part I is a patent survey arranged in a detailed classification, Part II comprises a bibliography of the references in Part I and</p> <p>P.T.O.</p>	<p>AGARD-AG-313</p> <p>Gyroscope Navigation Stabilisation Coriolis effects Gyroscopic forces Tops</p>	<p>AGARDograph No.313 Advisory Group for Aerospace Research and Development, NATO</p> <p>THE ANATOMY OF THE GYROSCOPE (A Report in Three Parts Comprising a Literature and Patent Survey Directed to the Gyroscopic and its Applications) by Frank W.Cousins, edited by John L.Hollington Published February 1988 296 pages</p> <p>This report on the gyroscope and its applications collates the technical information to be found in the patent literature, augmented by that residing in the text books and technical journals. The report is in three parts; Part I is a patent survey arranged in a detailed classification, Part II comprises a bibliography of the references in Part I and</p> <p>P.T.O.</p>	<p>AGARD-AG-313</p> <p>Gyroscope Navigation Stabilisation Coriolis effects Gyroscopic forces Tops</p>
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ISBN 92-835-0441-0	ISBN 92-835-0441-0
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SUPPLEMENTARY

INFORMATION

Part I
AD-A197162

ADDENDUM AND ERRATA (to Parts I and II)

Part I. P.47. Under 13.35 Cryogenic Gyroscopes insert European Patent Specification 0297059

Part I. P.112. For 2585**6 read 2585886 (bottom right hand column)

~~Part II. Piv. For Derek Lever read Derek J. Leaver.~~

ERRATA